PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1925

Issued April, 1927

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1927

PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

E. W. ALLEN, *Chief, Office of Experiment Stations.*
WALTER H. EVANS, *Chief, Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF

D. W. MAY, *Director.*
T. B. MCCLELLAND, *Horticulturist.*
H. C. HENRICKSEN, *Agriculturist.*
G. DIKMANS, *Parasitologist* [1]
C. M. TUCKER, *Plant Pathologist.*
R. L. DAVIS, *Plant Breeder.*
J. O. CARRERO, *Assistant Chemist.*
J. A. SALDAÑA, *Junior Scientific Aid.*
A. ARROYO, *Minor Scientific Helper.*
C. ALEMAR, JR., *Principal Clerk.*

---

[1] Transferred to Bureau of Animal Industry, United States Department of Agriculture, June 8, 1926.

PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.

Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C. April, 1927

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1925

CONTENTS

REPORT OF THE DIRECTOR

By D. W. May

Agricultural production in Porto Rico showed an increase during the fiscal year 1925. The production of sugar cane, the leading crop, was the largest in the history of the country, notwithstanding the fact that the price of sugar was less than since 1914. Coffee brought good prices, and the fruit industry prospered. Increased production is attributed to employing better fertilization and methods of cultivation, practicing rational systems of rotation, growing improved varieties of economic plants, and introducing purebred livestock.

LIVESTOCK

The station since its inception has strongly stressed the need of importing improved breeding stock into Porto Rico, and has benefited the local industry by lending purebred sires for breeding, by assisting farmers to procure better stock from the States, and by distributing surplus station-bred animals at a nominal price to all parts of the island. So far as known, the station introduced the first registered horses, cattle, and pigs into the country. The ever-changing economic conditions have brought about a difference in the use of certain of the domestic animals. Horses, once saddle-bred or used to draw light vehicles, are being replaced by the automobile. Cattle, used in the early days to cultivate the soil and for heavy transportation, are rapidly giving way to the tractor in the field and to the auto-truck on the highway.

The native cattle are good foundation stock. They are large-boned, excellent work animals, and their upkeep is small. They are slow to mature, however, are poor milkers, of poor beef form, and show a lack of selection in breeding. The station, by crossing native cows with purebred sires, has developed a herd carrying fifteen-sixteenths Guernsey blood. A few purebred heifers have been added to the herd. Each succeeding generation has steadily increased in milk

production. Some of the three-quarters bred cows have yielded over 5,000 pounds of milk annually, and the purebreds with first calves an average of 4,500 pounds annually. The station has amply demonstrated that early development, improved conformation, and increased milk production can be brought about by using purebred sires, and that, given the good care to which they are accustomed in the North, purebred animals can be developed in Porto Rico. Under the present conditions, however, the breeder is advised to build up his herd by introducing purebred sires of the breed he fancies most and to confine his efforts to breeding either for beef production or for dairy qualities.

DAIRYING

Profits from raising cattle for dairy purposes give promise of exceeding those obtained from any other branch of animal industry. Demands for beef and dairy products continue to increase. The

FIG. 1.—Cheddar, Swiss, and Edam cheese made at the Porto Rico Experiment Station

imports of the latter are among the largest of the island, and were valued at $2,039,221 during the year. Probably the greatest demand of the present is for fresh milk, which brings the highest returns of the dairy products. Although dairying is on the increase, in time it will be impossible to market all the milk that is locally produced. A surplus of the commodity can best be used in the form of butter and cheese. The station, anticipating this situation, has made some experiments to determine what factors influence butter and cheese making under tropical conditions. Results of the experiments so far indicate that sweet cream butter and several kinds of cheese can easily be made without the use of ice, and that a surplus of milk can be converted into salable products for local consumption. Cheddar, Swiss, Stilton, and Roquefort cheese have been made at the station (fig. 1), the proper organisms having been isolated from imported

Stilton and Roquefort cheeses. Powdered rennet, which can be readily gauged to any quantity of milk, has given the best results when used with milk which was carried over night and mixed with that obtained the next morning.

REFORESTING

Mahogany (*Swietenia mahagoni*) (fig. 2), horsetail tree or Australian ironwood (*Casuarina equisetifolia*), and Maria (*Calophyllum calaba*) are making the best growth of 60 acres of forest trees planted in 1924 by the station.

A number of economic questions enter into the problem of reforesting land in Porto Rico. Where the trees have been cut from the land the soil is deficient in nitrogen. To make these lands an agricultural success they should be planted with a leguminous tree or

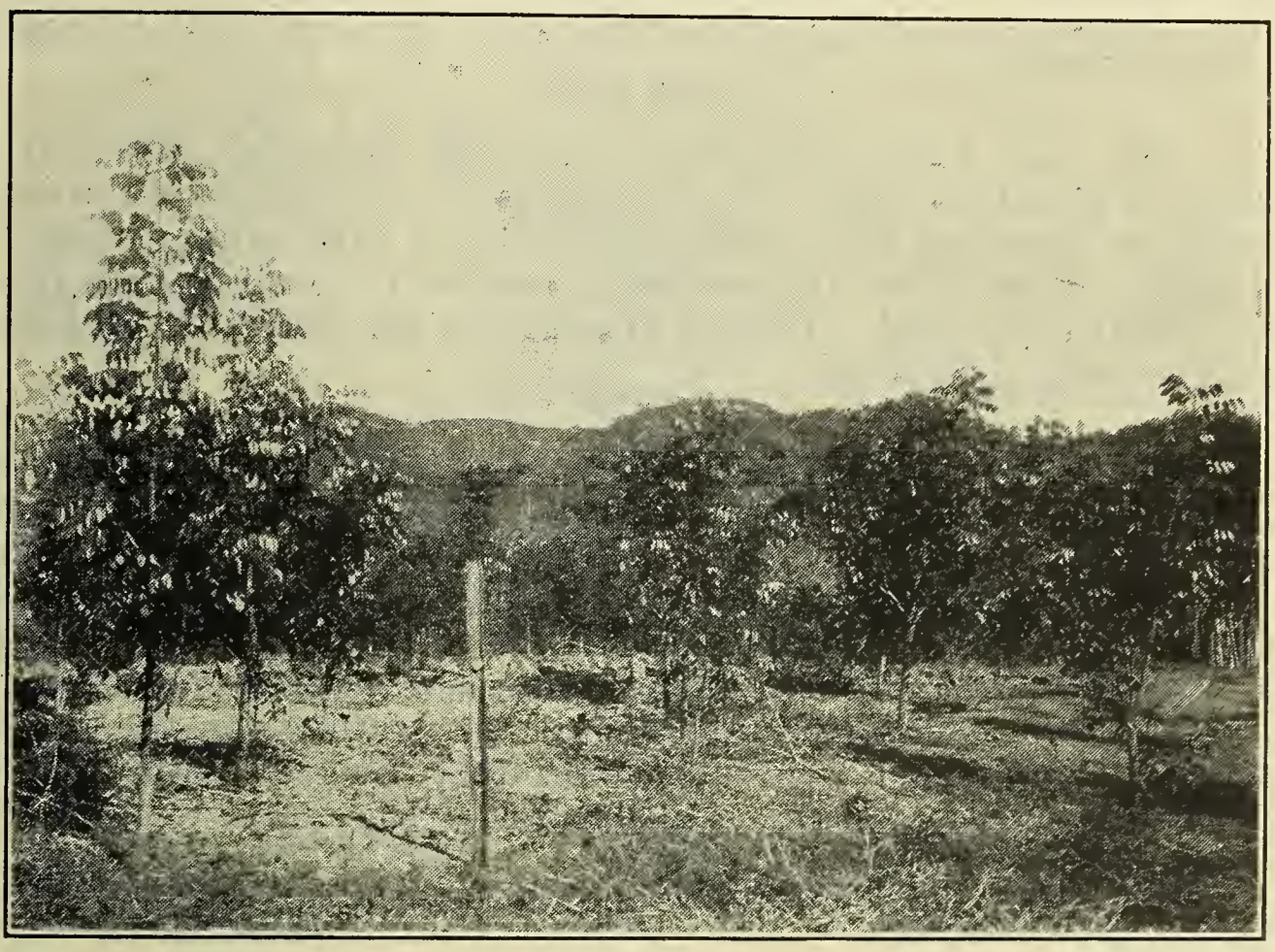

FIG. 2.—One-year-old mahogany trees at the Porto Rico Experiment Station

with a legume as a catch crop. Tree planting should be done with judgment and a look into future needs. Forest trees make rather slow growth, and if the farmer of small means would derive some return from his land while soil improvement is going on he should plant early-maturing trees of economic importance. This planting may consist of fruit trees, such as citrus, coffee, or cacao, and if others, legumes as a nurse crop. Forest trees should be of a type not readily destroyed by livestock if the land is to be utilized for grazing while the trees are in process of development.

FORAGE CROPS

The areas planted with elephant grass (*Pennisetum purpureum*) and Guatemala grass (*Tripsacum laxum*) were extended throughout the island. The grasses vary in yields under different methods of culture. The Guatemalan variety seems to be the more highly favored by ranchmen. It makes quicker growth than does elephant

grass, is more succulent, and is consumed in greater percentage per plant by stock. A well-balanced green ration may be obtained by planting velvet beans in the stubble remaining after each crop of Guatemala grass is cut. Uba cane is also highly recommended as stock feed and perhaps can be more economically converted into milk than into sugar when the price of the latter is low and transportation charges are high.

Clovers, including white, red, sapling, mammoth, alsike, bur, crimson, and peavine varieties, alfalfa, and hairy vetch grown from seed imported from the North were not a success at the station even when inoculated with the proper nodule-forming bacteria. Further trials may render these crops adaptable to island conditions. Lespedeza and Bokhara, or sweet clover, promise the greatest success for Porto Rico. When these varieties are planted in inoculated soil they bid fair to spread over the island, improving the soils and providing increased forage.

SUGAR CANE

The year was fairly prosperous for sugar cane, but the cost of production remained high. The station is continuing to aid the sugar industry by breeding high-yielding varieties of cane proving immune to disease. Each year an increasing number of seedlings are rigorously selected for trial. During the past season over 100,000 seedling canes were produced.

COFFEE

Coffee brought an increased price during the year, and growers devoted more attention than formerly to the cultivation of the trees and planted varieties which were introduced and disseminated by the station. The repeated efforts of the station to induce growers to fertilize the crop are beginning to bear fruit. Low-yielding varieties should be replaced with high-yielding, disease-resistant varieties, the seed of which may be obtained from the station for the asking. Planters are also urged to prepare thoroughly and cultivate the soils intended for coffee, to change the variety of trees used to shade the crop, and to live on their plantations, when possible, in order that they may give the industry the full attention it requires.

MARKETING AGRICULTURAL PRODUCTS

Knowing how to market a crop is probably one of the most important requirements of modern agriculture. Success depends primarily on the kind of preparation given the crop or on the method followed for preserving the manufactured product. Perishable food products spoil very quickly in the Tropics and may be either greatly improved or rendered useless by certain processes of fermentation. Many otherwise waste products can be saved by drying and canning. Tons of overripe, unshapely grapefruit, for example, are now profitably canned and marketed at leisure on the mainland.

The station has worked assiduously for 20 years in introducing, growing, and disseminating the best varieties of mango from different parts of the world, and is now endeavoring to provide a profitable outlet for surplus quantities which are prevented by quarantine regulations from being exported. Methods of canning have been developed as a means of utilizing the fruit and give promise of becom-

ing of commercial importance. The canned product has the consistency and appearance of the peach. Experiments in canning the avocado have not been very successful. The fruit is spoiled by cooking, absorbs too much salt when canned in brine, and is softened or dissolved, losing its character, when preserved in salad oils.

CACAO

Cacao yields fairly well in Porto Rico, but is not of the best quality. Of three varieties used in a local factory that from Venezuela ranks highest, and the varieties from Porto Rico and Santo Domingo next, in the order named. The difference in quality is probably due to the different methods used in curing. The Venezuelan variety is coated with earth at the close of the fermentation period.

Cacao beans when removed from the pod are embedded in a white slimy pulp which readily ferments. Fermentation causes the pulp to break down, releasing the seeds, and is accompanied by characteristic odors, especially of acetic acid. Fermentation, however, does not favorably affect the development of aroma within the bean. The aroma is developed by the action of flavor-forming enzymes in the bean, and an excessive production of acetic acid not only inhibits the action of the enzymes but also lowers the quality, especially the flavor, of the beans.

Results of experiments made with various substances as coatings for the beans at the end of the fermentation period showed a favorable influence on the quality of the resulting product. Clay and natural lime gave the best results of the several applications tried. Improvement in quality of beans was due partly to the neutralization and elimination of the acids forming in the slimy pulp by fermentation and partly to coating or sealing the beans, which then retain their aroma.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

MANAGEMENT OF CANE SOILS

Further studies were made of nitrogen utilization by cane soils. The second-plant cane crop, grown under treatments with nitrogen, legumes, and lime, was cut early in the year and crop yields of the different plats were recorded. Four stools in different parts of each plat were preserved to compare the proportion of trash, leaves, and tops with clean cane. Trash, leaves, and tops corresponding with the stools were preserved for analysis to learn the quantity of nutrients they extracted from the soil and of loss when they were burned. Data were obtained on all the fertilizing elements extracted by the crop, the quantity returned to the soil in the trash, and the quantity lost when the cane was carted away.

Samples of soils under treatment and from a check plat were taken to learn what fertilizing elements they contained and their acidity and lime requirements. Changes taking place in the various plats during treatment and the effect of each treatment on the soil were readily determined because the original composition of the plats was known.

The trash, leaves, and tops from the harvested plant crop were used as a mulch on sections of the field where mulching was required,

and quickly burned on other sections where a first ratoon crop was to be grown. No potash or phosphoric acid was applied to the crop. Nitrogen, the only fertilizer used, was applied in the form of ammonium sulphate to one section and as sodium nitrate to another. A third section was left to serve as a check. Table 1 gives the results of the test.

TABLE 1.—*Comparative yield in tons of second-plant cane plats under different treatments*

Plat series	Trash burned			Trash plowed under		
	No legume	Legume plowed under	No legume	Legume plowed under	No legume	Legume plowed under
Limed:	*Plat 1*	*Plat 2*	*Plat 3*	*Plat 4*	*Plat 5*	*Plat 6*
A	32.864	36.832	30.200	32.430	29.600	[1] 33.180
C	48.520	49.320	49.683	51.861	44.565	[2] 45.880
E	47.108	47.840	47.311	48.860	41.620	43.330
Unlimed:						
B	33.100	36.960	35.000	38.000	33.810	[1] 39.277
D	48.110	50.224	48.710	51.600	44.180	[2] 46.000
F	46.053	48.000	46.416	47.200	42.300	[3] 44.280

[1] No nitrogen. [2] Nitrogen as $NaNO_3$. [3] Nitrogen as $(NH_4)_2SO_4$.

In addition to the differences resulting from the various treatments given the plats, another and perhaps the main difference resulted from the use made of the crop residues and from the agency of a green-manure crop. To learn something of the behavior of cane leaves and trash when buried in the ground, the dry, finely ground cane leaves that were saved for chemical analysis were mixed in different proportions with 200 grams of a red clay soil, chosen because of its low content of nitrogen and phosphorus. The test was carried on for 65 days, the different treatments being examined for ammonia and nitrate nitrogen every sixth day for the first 30 days and every tenth day for the remainder of the period. The test was repeated under similar conditions except that a river loam which was fairly rich in lime was substituted for the red clay soil. The checks in these tests failed to give closely concordant results except in a few instances where the smallest quantities of leaves were used.

EFFECT OF SULPHUR AND SULPHUR COMPOUNDS ON SOILS

In continuation of experiments made to determine the value of sulphur as a fertilizer for Porto Rican soils two crops were raised. As was previously the case, the pots which were treated with sulphur, whether used as sulphur or as gypsum, showed slight increase in plant growth over pots receiving no sulphur. The soil under treatment is deficient in phosphorus. Sulphur when used alone gave only insignificant gains as compared with nontreatment, but when used as sulphates showed considerable gain over both nontreated and sulphur-treated pots. Significant gains resulted only when the sulphur was accompanied by phosphorus, but the increase was smaller than when phosphorus alone was used.

ANALYTICAL WORK

During the year analyses were made of samples of the various field crops under experiment, cane leaves, trash, tops, and bagasse, and the juice of varieties of cane from 36 plats under observation. Soil samples from the various plats under treatment were analyzed to determine what changes took place in composition and texture as the result of treatment. Analyses were also made of 460 samples of cane juice as well as a few samples of guanos and soils that were sent to the station.

REPORT OF THE AGRICULTURIST

By H. C. Henricksen

PINEAPPLE INVESTIGATIONS

Pineapple production in Porto Rico has fluctuated within wide limits since commercial cultivation of the crop began. In 1910 some 277,000 boxes of fruit, valued at $555,000, were exported. Production increased until 1915, when 552,000 boxes, valued at $1,723,000, were exported, and decreased during the next four years, only 116,000 boxes being exported in 1919 and 140,000 in 1920. Production again slowly increased, and in 1925 some 342,547 boxes, valued at $1,046,000, were exported. The fluctuation was partly due to a lack of knowing how to solve various problems connected with the industry. Fields did not continue to produce satisfactorily and new soils failed to produce as well as they were expected to; fertilizers did not always give the desired results, and the crop itself seemed to be deteriorating. Crop deterioration, however, was partly overcome by introducing several million slips from Cuba in 1921, 1922, and 1923, and by planting in suitable soils in the mountain districts. To learn the answers to other problems, including how to produce slips equally as good as those from Cuba, obtain maximum yields from using fertilizers, and determine the suitability of soils before planting, the station began a series of pineapple-production investigations, the results of which have proved to be of immediate practical value to local planters.[1]

SOIL MOISTURE

Results of investigations show that growing plants of the Red Spanish variety, 6 to 10 months old, transpire on the average 3 per cent of their weight every 24 hours. At this age each plant weighs approximately 1 kilogram, and, therefore, transpires 20 to 40 grams each 24 hours.

A method for determining the capability of a soil to deliver 20 to 40 grams of water to a well-rooted plant was developed by using homemade soil points. These were cylinders made from brick clay. After being well baked they measured 1 inch in diameter and slightly more than 5 inches in length, and after the ends were shellacked the cylinders had an absorbing surface of 16 square inches. Their average weight was 138 grams when dry and 164 grams when saturated, which was an increase in weight of about 19 per cent. Several cylinders were weighed and then buried in the soil about 6 inches deep

[1] The results have been published for general dissemination in mimeographed numbers of Agricultural Notes, available copies of which may be had upon application to the agriculturist.

and a foot apart. After 24 hours they were taken up, brushed, and again weighed. The gain in weight by all the cylinders divided by the number used showed the average quantity of moisture absorbed from the soil by each cylinder. The quantity of moisture absorbed in a certain time depends upon moisture content, which varies in different soils. A soil delivering an average of 5 grams of water each 24 hours to each cylinder can be depended upon to supply 20 to 40 grams to a well-rooted pineapple plant in the same length of time. It is concluded, therefore, that pineapple plants are not suffering from drought when grown on soils in which soil points continue to absorb 5 grams of moisture every 24 hours. By the use of soil points it was found that an excess moisture content was a problem more frequently than a deficiency.

SOIL AERATION

Many seemingly adverse conditions in pineapple fields were found to be the result of poor soil aeration. Lack of aeration may be caused by high water content, but frequently it is due to the physical composition of the soil and the state of its colloidal matter.

The state of the c lloidal matter in the soil may be determined by stirring a sample of soil with water and allowing it to stand for about 30 minutes. If the colloidal matter is in a state of perfect flocculation the soil will settle in that time, leaving the supernatant solution clear. If the colloidal matter is not in a state of perfect flocculation the soil will be a longer time in settling. The length of time required for settling may be used as a rough measure to determine the suitability of any soil for pineapple growing. In general, the more rapidly the soil settles the more suitable it is for pineapples, provided that the reaction of the soil solution is distinctly acid. The problem of aeration is serious at times for planters using paper mulch. Mulching has been used on a limited scale during the last two years and has been found to benefit soils that dry out during prolonged periods of drought. On the other hand, the results of the last year's investigations show that mulching is detrimental on the same kind of soils or on any soils retaining water nearly to the limit of saturation during prolonged rainy periods. The damage caused has been ascertained to be due directly to lack of aeration.

SOIL REACTION

Results of the investigations also show that a soil yielding a solution with a hydrogen-ion potentiality of 7 or over is not suitable for pineapple growing. A soil may prove to be suitable when the pH value is well toward 6 and the colloidal matter flocculates well; on the other hand, soils giving a pH value of 6 and poor flocculation are not likely to prove suitable. A soil may be said to be suitable when the pH value is much below 6 and the solution settles quickly. At least this holds true for all the Porto Rican soils thus far examined.

IMPROVING UNSUITABLE SOILS

Results of the last year's investigations show that (1) the suitability of a soil for pineapple growing may now be determined before planting; (2) it is possible to learn whether an unsuitable soil can be made

suitable, and if so, whether economically; and (3) if a rational system of rotation is practiced, a field can be made to produce more than two crops of pineapples.

An area which is not sufficiently aerated, due to an overabundance of moisture, should be thoroughly drained, when possible. Soils containing an overabundance of fine soil particles are benefited by treating with coarse, organic matter. Muck at the rate of 10 tons per acre is giving excellent results on a sandy soil where the particles are too fine for perfect aeration. Muck is, of course, not always available, but several kinds of plants can be plowed under instead. *Crotalaria juncea* is suitable for growing on sandy soils, and *C. striata*, *Tephrosia candida*, and pigeon peas (*Cajanus indica*) also give good results. Even *Urena lobata*, which grows wild on most sandy soils, may be used to good advantage, provided it makes a close stand.

Sulphur is the best treatment for unsuitability resulting from a high pH value and deflocculation of the colloidal matter. Five hundred pounds per acre should be sufficient, but a ton or more may be needed if the soil has a high lime (calcium carbonate) content.

To test the soil for carbonates, stir a sample with water and eliminate the lighter particles. Spread the remaining soil on a plate and add a few drops of hydrochloric acid. If much effervescence takes place the soil should not be used for pineapple growing, and can not profitably be made suitable by an application of sulphur. The colloidal matter in most subsoils is in a state of flocculation, and subsoiling may be beneficial when flocculation of the surface soil is needed. The benefit to be derived from subsoiling, however, is contingent upon the state of the colloidal matter and the degree of acidity of the surface soil and the subsoil. Five per cent of the subsoil may be sufficient to bring to the surface, but the approximate quantity necessary can be determined by mixing the surface soil and the subsoil in various proportions, stirring the mixtures in water, and determining the rate of settling.

Puddling, due to cultivating when the soil is too wet, may be remedied by working the area when the moisture content is most favorable for producing crumb structure, followed by planting with cover crops. Continuously cropping a soil with pineapple plants may result in an unsuitable soil. The local practice is to harvest two crops from the field before replanting. A soil having good crumb structure and a fairly high content of organic matter may be successively replanted three or four times, but better results will be had if the pineapple crop is rotated with sugar cane or with some cover crop.

SULPHUR

During the last three years sulphur has been used in varying quantities on soils ranging from light sand to heavy clay. Results of an experiment, started in 1922 to determine the degree of soil acidity produced by sulphur and the effect on the pineapple plant, showed that applications of 1,000 to 2,000 pounds per acre changed the pH value from 6 or 6.2 to 3.6 in 2 months, and at the end of 4 months to 3. After 6 months the reaction gradually changed and at the end of 12 months it was again between 6 and 6.2. A comparison of the treated and check plats showed that sulphur was beneficial to the pineapple plant. Weed growth was very much depressed by sul-

phur, the plat receiving treatment at the rate of 2,000 pounds per acre producing none. Mole crickets were not to be found as long as the pH value was between 3 and 4, although crickets and weeds were abundant in the check plats. The pH value changed to 2.8 in plats receiving sulphur at the rate of more than 2,000 pounds per acre, and to 2 at the end of 2 months in one plat of poor sandy soil receiving sulphur at the rate of 5,000 pounds per acre. The reaction in all cases returned to 6 to 6.2 before the end of 12 months. Applications of sulphur above 2,000 pounds per acre depressed the growth of pineapple plants according to the character of the soil. In one plat where the soil was a heavy loam containing much organic matter sulphur applied at the rate of 6,000 pounds per acre did no more damage to the crop than was done on another plat of sandy soil treated at the rate of 4,000 pounds per acre.

The effect of sulphur on soil nematodes was determined by growing potted dahlias in heavily infested soil instead of the pineapple plant which is not a good indicator, although it may be damaged by the pest. The results showed that dahlias can be grown on heavily infested soil so long as the pH value remains well below 5. This would seem to indicate that pineapples growing on nematode-infested soil might be benefited by sulphur applied at the rate of 1,000 pounds per acre.

FERTILIZING

The problems connected with pineapple fertilizing are many and complicated. Questions dealing with forms and combinations of nitrogen, potassium, and phosphorus best suited to the growing crop and proper time and rate of application have been partly answered. Ammonium sulphate has proved to be a suitable form of nitrogen on all soils under all conditions. Organic forms may be used when the soil is fairly acid and the colloidal matter is flocculated. With deflocculation of the colloidal matter and a pH value above 6, organic ammoniates, such as cottonseed meal, dried blood, and tankage, are not suitable, at least not until the adverse conditions have been remedied.

Sodium nitrate and calcium nitrate may be used on fairly acid soils containing large quantities of organic matter; otherwise, nitrates should not be used. In some of the latest but uncompleted experiments potassium nitrate has proved to be unsuitable for plant growth, even on acid soils having a high humus content. Phosphorus in the forms of ground steamed bonemeal, and acid phosphate has not given definite results when applied to growing plants.

Results of tests with soil samples from many fields on which pineapples are growing showed that nitrogen and potash were needed in large quantities. The actual quantities required at any time in any soil are, of course, not readily determinable by chemical analysis. Plats failing to yield 50 milligrams of water-soluble nitrogen per kilogram of soil responded to an application of nitrogenous fertilizer. Likewise, plants failed to attain maximum growth on plats the potassium content of which was not upwards of 100 milligrams per kilogram of soil. A 1 per cent citric-acid solution was used for extraction. A method for determining the weight of the soil, using these figures, was worked out. To learn whether the use of large quantities of fertilizer would pay, nitrogen and potassium each in quantities of 30 to 40 milligrams per kilogram of soil were applied to one group of plats;

the quantities were doubled on a second group and tripled on a third. Results as measured by plant growth were very much in favor of the heaviest application.

In another experiment a plat was fertilized every 12 weeks with a mixture carrying 100 milligrams of nitrogen and 150 milligrams of potassium per kilogram of soil. A second plat was fertilized every 6 weeks with the same mixture, using half the quantities applied in the first instance. Results were again in favor of the heavier application at longer intervals. The results correspond with those of pot experiments and show that the pineapple plant does not attain maximum growth unless it is grown on a soil which is high in nitrogen and potash. However, considerable loss may result from an effort to keep the elements high, as is illustrated, for example, in the last-mentioned experiment, in which one application was made in the rainy season and was followed by more than 3 inches of rain during the next 24 hours. The soil was sandy and leached out very heavily, results of tests made 24 hours later showing that only 27 milligrams of nitrogen and 38 milligrams of potassium per kilogram of soil remained. Under similar circumstances the applications evidently should be smaller and more frequent. The results show the advisability of making soil tests to learn whether leaching has occurred, in which case another application should be made immediately to prevent the plants from starving.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

EFFECT OF VARIATION IN DAY LENGTH ON GROWTH OF CERTAIN PLANTS

Studies of photoperiodism were confined to crop plants of local economic importance. Plantings of beans (three varieties) and sweet potatoes (two varieties) were made at four-week intervals. One group is kept under normal light conditions; in the second the illumination is supplemented by electric light throughout the year so as to approximate the length of day for June in this latitude; and for the third group the light exposure is kept at the December day lengths. Most of the plants are left in the group in which they started, but some are shifted from one group to another. As was the case in previous tests, both growth and blossoming of some species are affected to a pronounced degree by the limited range in day length for this latitude. Other species, however, are affected to a lesser degree. Many experiments will have to be made with the latter before definite conclusions can be drawn. Measurements of growth, date of blossoming, and date and weight of crop are being recorded for the plants under test.

COFFEE

Fertilizer experiments with coffee continue to show that production is strongly influenced by the kind of fertilizer applied. In a long-term cooperative experiment comparing both complete fertilizers and nitrogen alone the former showed pronounced superiority over the latter in regard both to the crop harvested within the year and that on the trees at present.

Records have been compiled showing the yields for eight years of another group of coffee trees grown on 40 plats, including checks, those receiving 1 element only and those treated with 2 or 3 elements in combination. Production per tree for the latest crop averaged 1½ pounds of dried coffee beans after the removal of the parchment. The record of production for this crop shows that potash, particularly when used in addition to nitrogen, was effective in increasing yield. In this crop 11 plats yielded better than the best check. These agree in one particular only. All received potash, 4 received nitrogen only in addition to potash, 1 received phosphoric acid in addition to potash, and 3 received both nitrogen and phosphoric acid in addition to potash. In the harvests for each of the eight years the group of plats receiving complete fertilizer and the group from which phosphoric acid had been omitted outyielded the unfertilized plats. The group receiving the potash alone outyielded the check for seven of the eight years. Nitrogen in heavy applications without potash very adversely affected fruiting, whereas the same quantity used in conjunction with potash proved beneficial rather than injurious. The appearance of the trees as well as their production was affected by the treatments, the plat receiving nitrogen alone in heavy applications producing only sparse foliage and poor growth in contrast with the luxuriant foliage and growth made by the plats receiving nitrogen and potash in combination. The highest yield for the eight-year period was made by the plat receiving nitrogen and potash at the heaviest rate, but no phosphoric acid. The last two yields from the plat were very high, averaging 2 pounds 15 ounces and 2 pounds 13 ounces, respectively, per tree per annum of dried coffee beans with the parchment removed.

In 1923 three series of forty 5-gallon containers were each filled with heavy clay, river loam, and beach sand to compare the effects of ammonium sulphate and sodium nitrate. Two seedlings were set in a container. Each soil group of 40 cans comprised 10 receiving 8 grams of ammonium sulphate semiannually; 20 receiving the same quantity of nitrogen in the form of sodium nitrate (10 in semiannual applications of 10 grams and 10 in monthly applications of 1.7 grams); and the remaining 10 cans, which received no nitrogen. Half the cans in each division, except that receiving ammonium sulphate, were given, in the form of flowers of sulphur, semiannual applications of sulphur equal to that carried in 8 grams of ammonium sulphate. The test was terminated 18 months after making the first application. Nitrogen was insufficient to sustain the coffee trees in beach sand. The seedlings growing in the river loam became heavily infected with disease, whereas those in the heavy clay soil grew vigorously.

Of the trees grown in clay, the group receiving sodium nitrate monthly and sulphur in addition ranked first in number of leaves and in weight of both leaves and woody growth. In height there was little difference between this group and the two groups receiving ammonium sulphate and sodium nitrate, respectively, in semiannual applications plus sulphur. Considering the growth as a whole, it was found that these two latter groups tied for second place. The group receiving monthly applications of sodium nitrate but no sulphur fell below these three leading groups in weight of both leaves and woody growth and in height, but in every particular it surpassed the group receiving in all an equal quantity of sodium nitrate given in semiannual rather than in monthly applications. The two groups given

no nitrogen ranked below all others in every particular, the differences in number of leaves and weight of foliage and woody growth being pronounced. The group receiving sulphur alone failed to equal the check, though this fact is presumably without significance.

Data pertaining to coffee fertilization were submitted for publication during the year.[2]

COCONUTS

Data on coconut production from various experimental plats would seem to indicate that considerable additional work must be done before definite conclusions can be drawn regarding the effect of different fertilizers on the crop. The wide variation in yield of individual trees receiving identical treatment and grown under apparently very uniform conditions makes plat yields less significant. In one plantation where 100 trees are under observation generous semiannual applications of fertilizer, continued through three years, fail to show definite effects.

ROOT CROPS

SWEET POTATOES

Numerous sweet-potato seedlings were tested, but, failing to equal in merit the named varieties already grown, had to be discarded. Field plantings for comparative purposes were attacked by slugs and rendered worthless.

YAUTIA, DASHEEN, AND TARO

During the last two years yautias, dasheens, and taros have been under test to ascertain the effect on them of storing at normal temperature. The large corms of the Penang taro do not keep more than a few days after digging, whereas 2 to 4 ounce cormels will keep longer, approximately half of those stored being still firm and in good condition at the end of 16 weeks. Of these, half remained firm from 8 to 10 weeks longer. The dasheens showed rot amounting to 10 per cent in 8 to 16 weeks, varying with the variety, and 50 per cent in 18 to 22 weeks. The yautias showed rot amounting to 10 per cent in 6 to 18 weeks and 50 per cent in 16 to 28 weeks. Rodents and mealybugs both proved to be troublesome during the storage tests.

CROTALARIA SPP. AS COVER CROPS

On May 20 plantings of Crotalaria, including *C. juncea*, *C. striata*, *C. usaramœnsis*, *C. retzii*, *C. saltiana*, and *C. anagyroides*, were made for comparative purposes. Heights were measured at approximately 3, 4, 5, and 6 months, and the weights of the green growth estimated at 15 and 20 weeks after planting. At three months, *C. juncea*, measured 110 inches, which was then two to three times the height of the other species. In ultimate height, *C. juncea* held first place, measuring 115 inches, with *C. striata* second, 110 inches, and *C. usaramœnsis* third, 90 inches. At 15 weeks *C. juncea* held first place in weight of green growth, yielding 13.2 tons per acre, with *C. usaramœnsis* second, producing 9.9 tons. At 20 weeks two species exceeded this production, *C. usaramœnsis* weighing 14.9 tons and *C. striata* 14.2 tons per acre, whereas *C. juncea*, past its prime, with little foliage remaining and blossoming about over, dropped to 12.6 tons. At 6 months *C. juncea*

[2] Porto Rico Sta. Bul. 31, Experiments in Coffee Fertilization in Porto Rico, copies of which may be had by addressing the director of the station.

had matured its seeds and died, whereas *C. striata*, *C. saltiana*, and *C. usaramœnsis* were still in full leaf. The latter at 9 months was the best in the field, well leafed and still flowering. *C. anagyroides* was too susceptible to thrip injury to be of promise for local propagation.

Since the Crotalarias are valuable cover crops, furnish mulching and temporary shade, and show such a wide range in growth, a knowledge of their specific differences should be acquired to enable planters to determine the species best serving individual needs.

MISCELLANEOUS FRUITS

Additional varieties of mango came into bearing during the year. Of these, the fruits of Gola and Peter's No. 1 are sweet, but insipid, and of inferior quality to many other imported varieties. Faizan has proved to be identical with Sufaida. Enuria is of good quality

FIG. 3.—Mangosteens (*Garcinia mangostana*). The fruits vary from a little over 1 to nearly 3 ounces in weight

and resembles Cambodiana in flavor, although it has certain distinctly different characteristics.

A number of exotic fruits came into production, including the mangosteen (*Garcinia mangostana*), of which two trees were imported about 1903. (Fig. 3.) These produced a few fruits in 1920 and are now bearing fairly well. The fruits have ripened during August and September and again during November and December, and vary in weight from a little more than 1 to nearly 5 ounces, with an average of 3½ ounces. The flavor resembles that of the grape and is refreshing and pleasing, although without decided character.

Euphoria didyma (*Nephelium glabrum*, S. P. I. No. 21245), a relative of the litchi, and introduced into Porto Rico by the station in 1908, fruited heavily during the summer. The fruit is small, deli-

cious, very sweet, and suggestive of maple sirup in flavor. The tree is frequently visited by bees and may prove to be a valuable source for honey production. Extensive distributions will be made of the variety.

The Florida Marvel blackberry has grown vigorously, but fruited very sparingly.

A mabolo tree (*Diospyros discolor*) is producing seedless fruit of good quality.

The Guinea oil palm (*Elaeis guineensis*, S. P. I. No. 36973), introduced by the station in 1916, fruited for the first time in the spring of 1925. (Fig. 4).

FIG. 4.—Guinea oil palm (*Elaeis guineensis*) in fruit

REPORT OF THE PLANT BREEDER

By R. L. DAVIS, and JOSÉ A. SALDAÑA, *Assistant*

FIELD CORN

Seedling characters of field corn were again studied, and high-yielding strains were isolated for use in developing selfed lines and continuing those already developed.

The serious effect of drought on seedlings was demonstrated in an August, 1924, harvest of 70 ear-to-row selections. Forty-four ear rows

that were severely wilted by drought when 11 days old produced an average of only 17.7 bushels of shelled corn per acre, as compared with 11 mediumly damaged rows which produced an average of 38.5 bushels, and 15 resistant rows, which yielded an average of 43.6 bushels.

A study for elimination purposes was made to determine the relation of leaf color of corn seedlings to their ability to resist drought. Seedlings from 116 ears of corn in germination flats when 8 days old were graded in leaf color according to Ridgeway's color standards. Only 13 of the seedlings proved to be drought resistant, enduring water starvation for two to three days longer than the others. Over one-fourth of the cultures having parrot-green leaves were resistant; in fact, 9 of the 13 resistant cultures had parrot-green leaves. Only 4 of 57 cultures having calliste or calliste-to-parrot-green leaves were resistant, and 2 of these may be ruled out because of their relatively small leaf area. None of the dark or grass-to-cossack-green cultures were resistant. These data indicate that corn seedlings with medium green leaves are more resistant to drought than are those having light or dark-green leaves.

In an effort to obtain high-yielding strains, ears were collected from Lajas, Peñuelas, Jayuya, Lares, Barranquitas, Toa Alta, Coamo, Aibonito, Cidra, Morovis, and San Germán. At present the corn from Peñuelas and Barranquitas seems to contain the breeding material giving the most promise. The Barranquitas corn is of interest because approximately 40 per cent of the plants bear two ears, whereas ordinarily, less than five per cent of the corn grown in Porto Rico develops more than one ear. The Peñuelas corn contains high-yielding elements.

In the yields for the fall crop of 1924 seed of 21 ears from Peñuelas averaged 25.7 bushels per acre; 11 from Lares, 21.3 bushels; 19 from Jayuya, 19.7 bushels; and 22 from Lajas, 18.4 bushels. Half of the ear rows from Peñuelas corn ran between 25 and 35 bushels per acre, whereas only one-sixth to one-tenth of those from the other three districts came within this range. Second season tests were made in 1925 with ear remnants from the highest yielding ears from each district. Castillear–1, the highest yielding ear in the fall of 1924, came from Peñuelas. If an average of the two crops is considered, Castillear–1 is found to have produced 49.1 bushels, and A. C.–19, the best yielder from Lajas, 32 bushels, and R. P.–1, the best yielder from Lares, only 26.1 bushels.. A two-year record is not available on Vincens Flint–2, the highest yielder from Jayuya in 1924, but an indirect comparison may be obtained from the yields of selfed lines in 1925. Five selfed lines from Castillear–1 yielded on the average 42 per cent more than 14 selfed lines from Vincens Flint–2 Furthermore, the highest yielding selfed line of the 39 tested was Castillear–1–3, a selection made from Castillear–1. Thus, in Mayaguez, corn from Peñuelas not only has given the highest average yield but also has furnished the highest yielding individual ear, which, in turn, has produced the highest yielding selfed lines.

SWEET CORN

Sweet-corn hybrids were produced by crossing the most vigorous pairs of strains in the 1924 crop, and a rigid elimination was conducted by growing native field corn in the same hills with sweet corn

and discarding all sweet corn of inferior growth. Of the 1924 selections made to obtain husk protection, strain No. 24–2–5 was a marked improvement over others and was only slightly damaged by earworms. The selections developed from sweet-corn kernels found on ears of native field corn proved to be superior to selections from hybrids resulting from crosses between native field corn and sweet corn introduced from the North. Selfed lines have been started from several of the more promising strains of pure native extraction.

SUGAR CANE

BREEDING

Field and chemical data were obtained in March, 1925, on the best 400 of 2,100 seedlings which had been set in the field in April, 1924, and many seedlings having no potential value for commercial purposes were analyzed to determine their relative value for breeding work. Seedlings containing 16.75 per cent of sucrose or over numbered 27 of 283 of the D–109 variety, 3 of 31 of the G. C.–1486 variety, and 7 of 22 of the S. C. 12/4 variety. These figures would seem to indicate that the chances of finding high sucrose seedlings are two-thirds greater in the S. C. 12/4 variety than in the other two kinds. Only the larger seedlings were tested but they represented a random sampling of each variety so far as sucrose was concerned.

Judging by the results obtained with the 1924 crop of cane seedlings, poor varieties may produce good seedlings, and vice versa. The variety E. K.–28, which is considered good, gave the poorest seedlings of any tested, all being small and sickly. Rayada, a mediocre variety, produced very poor, slow-growing seedlings, and S. C. 12/4, one of the best varieties grown in Porto Rico, bore seedlings showing inferiority to the parents in size. The seedlings of E. K.–28, Rayada, and S. C. 12/4 were grown in 10-inch clay pots and given better treatment than the D–109 seedlings, which were grown in flats. The latter, however, made the best growth. G. C.–1486, which is a mediocre variety and not so extensively propagated as D–109, produced very good seedlings, some of which excelled the parent. Only one, however, seedling MPR–50 (nursery No. 4 G.C. 1486–1), was selected for further testing.

The original stool of seedling MPR–50 in 1924 yielded 84 pounds of cane, more than did all the other varieties, except Cristallina, which gave 90 pounds per stool. The yield of sucrose was 15.95 per cent, and of purity 88.3 per cent. Assuming a 100 per cent stand 5 by 3 feet to have been obtained, the variety yielded at the rate of 121.41 tons of cane and 12.274 tons of sugar per acre. The variety seems to have early maturing qualities, since it yielded heavily at 16 months after seeding, or 10½ months after transplanting to the field. In a field having poor drainage the variety made a second-year growth surpassing that of the varieties D–117, S. C. 12/4, and H–109.

The variety makes strong, erect growth, germinates well, and stools heavily, the original stool bearing 24 canes and 9 suckers. The stems are zigzag and tumid, about 4 centimeters in diameter, and of yellowish green color flushed with red. A conspicuous ring of rather short, brownish cracks lies immediately below the glaucous band and sometimes invades the area. The bud is round, exceeding the growth ring

by 3 millimeters, with blunt and ciliated apex, narrow margin, subdorsal germination, and fine, smooth hairs on the shoulders and on the margin below the apex. The growth ring is narrow, undefined, even, and concolorous with the internode. The root band is 4 to 6 millimeters in breadth, concolorous with the internode, and bears 3 or 4 conspicuous rows of rudimentary roots. The leaf scar is glabrous, the glaucous band constricted and wax heavy, and the leaves are green and spreading.

TESTS OF INTRODUCED VARIETIES

P. O. J. 2725, a variety supposed to have come from Java and recently introduced from Tucumán, Argentina, continues to give promising results. This variety has been widely distributed in small quantities among local planters and adapts itself to a wide range of conditions, thriving best where the rainfall is abundant, and also doing very well on poorly drained soils. P. O. J. 2725 will probably supplant varieties more susceptible to mosaic, and also the Uba cane, which is unstable in yield of sucrose and purity. Only one-tenth of 1 per cent of the crop of P. O. J. 2725 has been affected by mosaic disease in Mayaguez, and about 1 or 2 per cent in Tucumán. Planted at the rate of one 3-eyed piece each in holes 5 by 5 feet on a 1/40-acre plat at Mayaguez, P. O. J. 2725 at 13½ months yielded at the rate of 49.7 tons of cane per acre. The crop was not affected when grown on a soil that was under water for three different periods of several days each. Grown on a 1/20-acre plat, P. O. J. 2725 at 18 months yielded at the rate of 77.4 tons of cane per acre. In a mill test at Central Coloso 2½ tons of this cane yielded 15.83 per cent sucrose and a purity of 84.7 per cent. A ton of the cane at 12½ months analyzed 15.25 per cent sucrose and a purity of 82.9 per cent.

Judging by the results obtained in Tucumán, where yields approximate 4 tons of sugar per acre during the relatively short growing season, P. O. J. 2725 should yield 6 to 8 tons per acre in Porto Rico, where the growing season is longer. The variety seems to be very early, arrowing the first part of November. It arrows profusely, beginning at the age of 5 months when planted in June. The variety should not be planted in April, May, or June, if best results are to be expected, because early arrowing tends to reduce yields. As an extra early crop it should be planted during the first three months of the year. The canes are soft and readily attacked by the stalk borer.

A number of other varieties introduced from the Far East by the station include P. O. J. 2727, P. O. J. 2714, Toledo, 36–M (sport of P. O. J. 36), Tekcha, Tjep. 24, and P. O. J. 2725, the last two of which were also introduced earlier from Tucumán. The most promising after the P. O. J. 2725 is variety P. O. J. 2714, which is a thick cane and makes vigorous and rapid growth. However, 20 per cent of the crop proved to be susceptible to mosaic disease at Mayaguez. The variety Toledo, a thin cane resembling the P. O. J. 312, is a prolific stooler and so far has been free from mosaic disease. It is not so vigorous as the variety BH–10/12. Cane P. O. J. 2727 made promising growth. Cane 36–M is very similar to cane P. O. J. 36, from

which it was developed, and 20 per cent of the crop was found to be infected with mosaic disease. The variety Tjep. 24 made rather vigorous growth while young, but slowed down later, whereas nearly all the other varieties rapidly increased in growth. This was true especially of cane P. O. J. 2725, which about doubled its first growth. Cane Tjep. 24 has so far been free from mosaic disease. Cane Tekcha resembles canes of the Japanese type, makes vigorous growth, and seems to be free from mosaic disease.

The following list gives the analysis (percentage) of single stools of the different varieties: P. O. J. 2725, 18.89 sucrose and 85.94 purity; P. O. J. 2714, 17.82 sucrose and 81.44 purity; P. O. J. 2727, 14.35 sucrose and 70.41 purity; Tjep. 24, 15.94 sucrose and 81.87 purity; Toledo, 9.1 sucrose and 50 purity; and Tekcha, 12.8 sucrose and 73.73 purity.

SPACING EXPERIMENT

To determine the optimum planting distance for maximum yield of cane and sugar with thin-stemmed prolific varieties, seed pieces of the varieties Java Unknown and Uba were planted 2 to 6 feet apart in rows 6 feet apart. In another series seed pieces of Java Unknown were planted 2 to 5 feet apart in rows 5 feet apart. Sufficient land was not available for planting the Uba variety in a 5-foot series. Plantings were made in duplicate with three rows per plat, and data were collected only on the middle row, or approximately on each 1/100-acre plat. Drought reduced the stands and necessitated making corrections on yield data for each plat. Table 2 gives the results of planting at the different distances.

TABLE 2.—*Analysis and calculated yield of Java Unknown and Uba cane planted at different distances*

Name of cane	Planting distance	Brix reading	Sucrose content	Purity	Yield of cane per acre	Yield of sugar per acre
	Feet	*Degrees*	*Per cent*	*Per cent*	*Tons*	*Tons*
Java Unknown	5 by 2	19.43	16.18	82.70	54.090	8.744
Do	5 by 3	19.46	16.37	83.47	29.440	4.968
Do	5 by 4	19.79	16.19	81.69	33.650	5.614
Do	5 by 5	19.57	16.12	82.38	30.750	5.127
Do	6 by 2	19.90	16.76	84.15	43.385	7.272
Do	6 by 3	18.27	13.29	72.80	34.544	4.224
Do	6 by 4	20.28	16.53	81.87	29.250	6.316
Do	6 by 5	20.21	16.97	83.97	39.747	5.183
Do	6 by 6	19.94	16.25	81.48	37.026	5.712
Uba	6 by 2	19.99	17.13	85.65	51.210	8.934
Do	6 by 3	20.15	16.75	83.11	45.960	7.668
Do	6 by 4	20.22	16.68	80.11	30.056	4.867
Do	6 by 5	20.14	15.85	78.67	26.789	4.249
Do	6 by 6	18.92	14.64	78.87	16.552	2.426

The sugar yield for both varieties was highest from the closest spacings, either 6 by 2 or 5 by 2 feet, and, although the sucrose percentages showed no marked differences for the different plats, the purity content tended to lessen with the wider spacing.

CULTURAL EXPERIMENTS

Notwithstanding the many methods followed for propagating the cane seedling, the data available comparing their relative values are

few. To obtain further information on these values, data were recorded on the vitality of seed, mortality, and growth of a number of seedlings which were grown at Mayaguez in the open with and without protection from the sun and wind. The experiment was divided into four parts: (1) Collection, storage, and seeding of arrows; (2) care of germination flats, sunlight exposure, and irrigation; (3) soil mixture, depth, and texture; and (4) optimum age for transplanting from the flats.

Serious loss in vitality of seed took place within three days after collection when fluctuation in moisture content was not prevented. The seed should, therefore, be planted as soon as possible after collection. S. C. 12/4 arrows collected during the last week of December gave a higher germination than did those collected about the middle of January. In a test made to learn the effect of germination of sowing wet arrows in layers varying in thickness from 4.4 to 11.6 millimeters the minimum depth produced the largest number of seedlings per arrow, whereas any marked increase in depth prevented germination of seeds lying at the bottom of the layer. Complete exposure to sunlight resulted in a healthy growth in all stages. Shading during the mornings of the first two weeks after transplanting not only stunted growth but also increased mortality. Seedlings of the variety D–109 increased in growth when they were transplanted at 2 weeks of age and immediately treated with Bayer dust. Deep germination flats gave better results than shallow flats. The month-old root systems of S. C. 12/4 grown in 6-inch flats, were about half as large again as root systems of the same age which were grown in 3-inch flats. Flats in the bottom of which unsifted coarse soil was placed showed a decrease in mortality over flats in which the soil was sifted throughout.

Tests were made in both germination flats and flats for transplanting to determine the comparative effect on cane of clay, powdered charcoal, manure, coconut fiber, and sandy river loam in varying quantities. Clay proved to be undesirable at all times, stunting the crop and increasing mortality. The germination flats made an increased stand when the top inch layer of soil was treated with powdered charcoal (one-third part), whereas the flats for transplanting when similarly treated showed increased mortality. Coconut fiber can not be recommended for use because it retains moisture and proves to be objectionable when the flats are exposed to rain. Well-rotted cow manure mixed to the extent of 50 per cent with sandy river loam, gave satisfactory results in both the germination flats and the flats for transplanting.

Transplanted seedlings grown on a mixture of equal parts of manure and sandy river loam showed a lower mortality than did those on 1 to 2 parts of the same mixture. Fully 30 to 65 per cent of the seedlings transplanted when less than 1 month old died. Seedlings should be transplanted between 60 and 70 days old to lessen the chances for death and facilitate ease in handling. At this age they will be 3 to 5 inches high, and the developing suckers can be used as a basis for roguing. Some of the B–3412 variety of seedlings, which were kept in germination flats 6 inches deep until 4 months old, made

such vigorous growth as to indicate the advisability of sowing deeply and controlling the rate of seeding to avoid the work of transplanting to pots.

ELIMINATING UNDESIRABLE SEEDLINGS

To determine what differences justifying early elimination occur in the growth of canes of varying ages, measurements and observations were made on cane seedlings at 2½, 3½, and 6½ to 7 months. Rather contrasting differences take place in cane seedlings of different varieties less than a month old. At 14 days two typical S. C. 12/4 seedlings were twice the size of two D–117 seedlings. (Fig. 5.) Contrasting differences in germination vigor also occur in S. C.12/4 and P. O. J.–2725 seedlings. At 2 to 3½ months old, seedlings may show a number of differences, many of which persist to maturity. Characteristic seedlings of FC–306 at 2 months are large and many-suckered, with recurved leaves; whereas, S. C. 12/4 seedlings of the same age are medium to large, and few-suckered, with saberlike leaves; and B–6308 seedlings are small, stocky, and many-suckered, with recurved leaves.

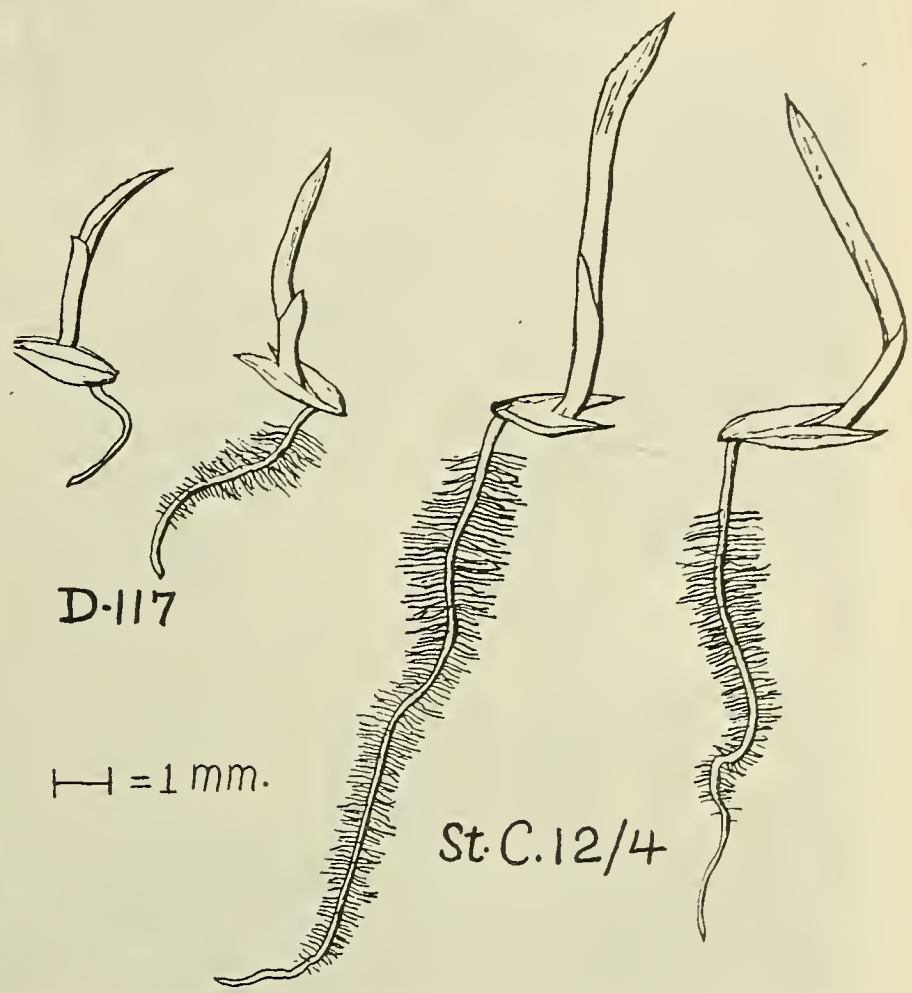

FIG. 5.—At one week differences are observable in cane seedlings of different varieties. The two D–117 seedlings on the left are less than half the size of those of St. Croix 12/4 on the right. (Drawn one week from date of seeding.)

With the exception of seedlings that germinate slowly and those having abnormal leaf coloring, elimination should be postponed until suckering begins, or the plants are 2½ months old. Rarely more than 10 per cent of the seedlings sucker before they are 2 months old. Leaf width, leaf shape, and position of suckers are relatively unimportant characters for elimination purposes because the differences are not sufficiently contrasting except in hybrid progenies of known parentage.

In the elimination work tests were made determining the relation of the early-suckering habit to the size of the stool nearing maturity. Notes were taken on approximately 1,000 seedlings of the varieties S. C. 12/4, FC–306, B–6308, D–433, and D–117. The many-suckered varieties at 2½ months had 10 times as many potentially desirable seedlings approaching maturity as were to be found among the few-suckered varieties of the same age. The superiority of the many-suckered seedlings, selected at 2½ months, is marked at 6½ months. (Fig. 6.) The number of potentially desirable seedlings at 6½ or 7

months may be doubled or trebled by increasing the number of seedlings to be germinated and by transplanting only those having many suckers at 2½ months. The practice of eliminating few-suckered seedlings at 2½ to 3½ months is desirable.

FIG. 6.—The superiority of many-suckered cane seedlings at 2½ months is marked at 6½ months. The row on the left consisting of seedlings of B-6308 selected for three or more suckers at 2½ months has made double the growth of the row on the right, consisting of seedlings with two or less suckers at 2½ months

REPORT OF THE PARASITOLOGIST

By G. DIKMANS

The work in parasitology was begun in 1924. The leading projects under investigation include: (1) A general survey of animal parasites affecting domestic animals in Porto Rico; (2) a study of the life history of *Necator suillus* and its possible relation to the problem of human ankylostomiasis in Porto Rico; (3) paradichlorobenzene as an anthelmintic; and (4) hookworm development in the latrine and the pollution of the surrounding area.

The small intestines of 60 pigs that had been slaughtered at a local abattoir were brought to the laboratory for examination. Of these, 24, or 40 per cent, were found to harbor a nematode provisionally determined as *Crassisoma urosubulatum* Aless 1909. Further detailed study of the nematode is necessary to make the determination abso-

lute. The number of nematodes found per pig ranged from 1 to 800–1,000. Forty per cent of the animals were infested with the thorny headed hog worm (*Macracanthorynchus hirudinaceus*). The common roundworm (*Ascaris lumbricoides*) was found in one animal. Nine of 18 pig stomachs examined contained nematodes. Five had a double infestation of *Hyostrongylus rubidus* and *Arduenna strongylina*. Two contained *H. rubidus* alone, and two others *A. strongylina* alone. The few lungs examined showed a high rate of infestation with lungworms, and a few of the large intestines the presence of *Oesophagostomum dentatum*. The feces of one of the animals was heavily infested with *Balantidium coli*, and several showed cysts of amœbæ.

No cattle were systematically examined, but casual observation in the slaughterhouse showed a high percentage of infestation with the liver fluke (*Fasciola hepatica*). Lung abscesses due to this parasite were found. Post-mortem examination of a calf showed the presence of ticks in large numbers and all stages of growth, *Snygamus laryngeus* in the larynx and upper part of the trachea, large numbers of lungworms, approximately 4,000 stomach worms (*Hæmonchus contortus*) in the abomasum, cattle hookworms (*Bunostomum phlebotomum*), and numbers of Cooperia in the small intestine, whipworms (*Trichuris ovis*), and nodular worms (*Œsophagostomum radiatum*) in the large intestine and cæcum, and liver flukes (*Fasciola hepatica*) in the liver.

The large intestine of one of the station heifers contained some Œsophagostoma and an undetermined species of the genus Capillaria. All the dogs coming under observation were infested with hookworm (*Ankylostomum caninum*). A number of the dogs harbored also roundworms, tapeworms, and coccidia. A cat was found to harbor a female hookworm (*A. caninum*). Chickens, turkeys, and one guinea hen harbored nematodes, cestodes, and trematodes. Unidentified ticks were collected from cattle, horses, and dogs and goats. Specimens of the horn fly (*Hæmatobia irritans*) were collected from animals in the dry section of the island. The fly was not found on the station animals, but some observations concerning the extent of its range and possible remedial measures may be desirable. Larvæ of the ox warble (*Hypoderma* sp.) were taken from imported cattle. Deer flies were seen in negligible numbers. Two imported animals which were infested with lice were clipped and sent to the dipping vat.

Examination of nematodes, taken from pigs at a local abattoir, failed to show the presence of *Necator suillus*. Comparatively few pigs were examined, however, and further observations may reveal its presence here or in some other part of the island. Unsuccessful attempts were made to infect pigs with the hookworm of man, confirming the results obtained by others making similar tests. Ackert's findings regarding the possible dissemination of the human hookworm by pigs were confirmed. He showed that eggs pass unharmed through the digestive tract of the pig and hatch in the feces. Apparently the pig is a factor to be reckoned with, since it may act as an agent in spreading hookworm infection, although immune to the disease itself.

Experiments to determine the efficacy of paradichlorobenzene as an anthelmintic were begun in March, 1924, about four months before the other work in parasitology was started. Experimental data are being prepared for publication.

The fourth project has received the greater part of the parasitologist's time and attention. For the purpose of the investigation, four pits 24 by 24 by 30 inches deep have been constructed. It is planned to reproduce in these pits as nearly as possible conditions as they actually exist in the pit latrine. Material known to contain hookworm eggs is to be placed in the pits and the material, the walls of the pit, and the soil surrounding the pit are to be examined for the presence of infective hookworm larvæ. The work is progressing slowly but satisfactorily and is too new yet to permit drawing conclusions.

In addition to his regular duties, the parasitologist acted as veterinarian of the station. The general health of the station animals was excellent. The usual cases of lameness in work oxen caused by traveling for long distances on hard roads were remedied by bathing the affected parts with a mixture of lead acetate and zinc sulphate (3 drams each) and water (1 pint), and by resting the animals for a week or 10 days. Post-mortem examination of an apparently healthy young animal which was found dead revealed an inflamed mucous membrane of the digestive tract. No other pathology was noted. The animal had had access to a solution containing arsenic, and probably died of poisoning. Post-mortem findings of an imported Shorthorn bull dying after a short illness disclosed conditions indicative of tick fever. The findings, however, could not be confirmed by blood examination. Two imported Guernsey bulls are suffering from a skin affection. The older of the animals has been at the station for several years and has had the disease for at least three years, practically the entire body being affected. The younger animal arrived at the station a year ago and has had the disease about four months, the ears alone being affected. No etiological factor has been isolated so far. Skin scrapings were submitted to the veterinary laboratory, Army Medical School, Washington, D. C., and to Bailey K. Ashford, School of Tropical Medicine, San Juan, P. R. The Army Medical School reports entirely negative findings. Doctor Ashford reports the finding of a new species of Monilia on the skin scrapings sent to him, and has prepared a vaccine of this organism. The animal is being treated with the vaccine at present.

REPORT OF THE PLANT PATHOLOGIST

By C. M. Tucker

COCONUT BUD ROT

Work on coconut bud rot was continued and a manuscript giving results of the investigations was submitted for publication.[3]

The results briefly summed up are as follows: *Phytophthora palmivora* (*P. faberi.*) is the causal organism of coconut bud rot in Porto Rico as it is in Jamaica, the Philippines, and India. The disease is transmissible from diseased palms to healthy, uninjured ones. The incubation period may vary from 2 to 10 months or longer. Organisms of the *Bacillus coli* type are present in decaying buds, but are not pathogenic. Inoculations made by wounding the bud are practically of no value, because the palms may be killed by decay of the most aseptically treated wounds. Conditions favorable to the disease

[3] Phytophthora bud rot of coconut palms in Porto Rico. U. S. Dept. Agr., Jour. Agr. Research, 32 (1926), No. 5, pp. 471–498.

include heavy rains and decreased evaporation occuring in sheltered locations and poorly drained soils. The earliest visible symptom of the disease is the death of the youngest leaf. (Fig. 7.) The most important period of infectiousness follows exposure of the young dead leaf bearing conidia and chlamydospores. As a control measure all infected palms should be destroyed as soon as the disease is detected. The strain of *P. palmivora* obtained from coconut bud rot, although indistinguishable physiologically and morphologically from some cacao-infecting strains, was not found to be pathogenic to cacao pods or seedlings. (Fig. 8.) Efforts to transmit coconut bud rot by means of infected seeds were not successful. Inoculations of dry, ripe coconuts resulted negatively, since the water-loving Phytophthora was unable to establish itself and the half-ripe inoculated nuts decayed and failed to germinate. These results agree with those obtained when the young seedlings are free from disease.

FIG. 7—Coconut bud rot produced by pouring a water suspension of of a pure culture of *Phytophthora palmivora* among the unwounded, unfolding leaves. Photographed 121 days after inoculation

The legislature of Porto Rico has enacted a law enabling the commissioner of agriculture and labor to take precautionary measures to combat plant pests and diseases. Coconut bud rot is the first fungus disease to be dealt with under the new law, and all diseased palms have been ordered destroyed. The plant pathologist is now acting in an advisory capacity in the campaign for the eradication of the disease.

LIGHTNING INJURY TO COCONUT PALMS

Occasionally lightning strikes and kills palms. In one case observed 11 palms occupying a circular area 50 to 75 yards in diameter were killed by the same bolt of lightning and leaf midribs were broken and leaves killed on the sides of the palms adjoining the damaged area. Lightning-struck palms show symptoms which can readily be distinguished from those caused by bud rot. Phytophthora bud rot destroys the bud and causes the death of the youngest leaves. The

older leaves may retain their green color and horizontal position for many months. When palms are struck by lightning the petioles collapse and the leaves turn brown and hang pendant from the crown. (Fig. 9). Bud rot is more likely to kill palms scattered over a wide area than it is to take all the palms of a restricted area.

A ROOT DISEASE OF VANILLA

Investigations to determine the cause and control of vanilla root disease have been previously described.[4] The rather unsatisfactory percentages of infection of inoculated plants grown in sterilized fiber is found to have been due to an inhibitory substance, probably tannin, which was produced during autoclaving of the moist fiber. Subsequent inoculations made in soil established the pathogenicity of the fungus (*Fusarium* sp.).

FIG. 8—Cacao seedlings inoculated with *Phytophthora palmivora* strains. (1) Inoculated with *P. palmivora* from cacao; (2) inoculated with *P. palmivora* from coconut. The coconut strains showed no evidence of pathogenicity to cacao. Photographed eight days after inoculation

A study was made comparing the growth of roots in situ in sterilized soil and in inoculated soil. Large plugged glass tubes of inoculated soil were used to receive surface sterilized descending aerial roots. The tubes when tied to the support on which the vine clings permit normal root development. One hundred per cent of the roots in the Fusarium-inoculated soil became infected, whereas all those in the tubes of sterilized soil remained healthy.

The fungus is able to grow in a soil when deprived of a living host and remain in a virulent condition for at least four years. The pathogenicity of the fungus has been shown to be due to the destruction of the cortex by a cytolytic enzyme causing the cell walls

[4] Rpts. Porto Rico Sta. 1923, p. 15; 1924, p. 28.

to turn brown and dissolve. The cambium and ducts are invaded only after destruction of the cortex cells is well advanced, and in no case observed were the hyphæ in the ducts developed sufficiently to prevent the passage of nutrients as occurs in cases of infection by

FIG. 9.—Coconut palm killed by lightning. Compare with bud-rot infected palm in Figure 7. In the right foreground may be seen a portion of a palm leaf hanging from a broken midrib. This type of damage is common on palms adjacent to those killed by lightning. It never accompanies bud rot

F. vasinfectum. Unsuccessful attempts were made to isolate the fungus from tissue taken from the margin back of the decayed area of diseased roots, further indicating that the fungus is not a vascular parasite. *F. cubense* has been shown to produce a toxic product causing cut banana plants to wilt when placed in filtrates of culture

solutions in which the fungus has been grown. Similar work with the vanilla Fusarium failed to cause wilting of bean and cotton seedlings.

Vanilla plants were successfully inoculated when the root organism was placed in wounds made in the stems. The internodes rotted, resulting in the death of the plant above the point of inoculation, in all cases except where new roots formed and came in contact with the soil. *F. cubense* failed to produce a diseased condition.

The problem of vanilla root disease is similar in some respects to that of banana wilt. Both diseases are caused by a Fusarium which is able to persist in infected soils for long periods. Vegetative propagation is commonly practiced with both host crops, and each shows varietal or specific variation in susceptibility. The vanillon, an inferior type of vanilla, is highly resistant. The vanilla plant produces germinable seeds, and resistant, valuable hybrids may be obtained by crossing it with the vanillon. Vanilla plantings have been reported usually as remaining healthy for three or four years. The crop develops best on a substratum of decaying matter and is for this reason frequently treated with forest rakings. Decomposition of the organic matter produces acid conditions which probably favor the growth of the Fusarium. Several series of pots are being prepared with soil reactions varying from pH 5.4 to pH 9.8 to determine their effect on the disease.

COTTON FUNGUS

Sea-island cotton is annually attacked by a fungus which spots the leaves, bracts, and bolls. The disease commonly occurs at Lajas, Isabela, and Quebradillas, the principal cotton-growing sections of the island. The leaves show circular, rather conspicuous, dark purple spots, which gradually bleach and turn gray in the center. Many of the centers drop, leaving the leaves with jagged holes. The bracts are similarly attacked. The bolls show a small purple spot which does not enlarge nor become ashen in the center. The fungus has not been observed to penetrate the boll. The causal organism is a Helminthosporium, which has been described as a new species, *H. gossypii*.[5] The fungus sporulates freely on the ashen centers of old spots, and has been isolated in pure culture. It grows on a wide variety of artificial media, but produces spores most abundantly on sugar-containing media. Leaves and bracts bear typical spots developing sufficiently for identification in three weeks when inoculated by spraying with a water suspension of spores and mycelim. The spots are well developed in five days. (Fig. 10.)

Unlike many leaf-spot diseases, the cotton leaf-spot disease is severe in dry weather. Examination of a field at Lajas during a drought so severe as to cause stunting of the plants showed spotting on nearly every leaf and partial defoliation of many of the heavily infected plants. Much new growth was found in the same field after about three weeks of rain, and the young leaves were then practically free from infection. Destroying all plants between seasons, as is done to combat the pink bollworm, probably would help to decrease the damage done by *H. gossypii*.

[5] U. S. Dept. Agr., Jour. Agr. Research, 32 (1926), No. 4, pp. 381–395.

STRAINS OF TROPICAL PHYTOPHTHORAS

An investigation to facilitate the work of identifying Phytophthoras attacking various tropical plants has been begun, comparing morphologically and physiologically 45 strains isolated from cacao, coconut, cotton, breadfruit, papaw, citrus, abaca, tomato, eggplant, *Odontodenia speciosa*, *Dendrobium maccarthiæ*, Hevea, Erythrina, Borassus, and *Hibiscus sabdariffa*. Cross inoculations also are being made. The results thus far indicate considerable variation in cultural characteristics on the media, including potato dextrose agar, potato agar, coconut agar, beef dextrose agar, oatmeal agar, and bean agar, used to make comparisons. Morphological variations in the size and shape of sporangia and size of chlamydospores seem to be fairly constant for various strains, but the variations are narrow. Probably the most striking characteristic is the highly specialized pathogenicity of the strains. In most cases a strain will cause disease only in the host plant from which it is isolated.

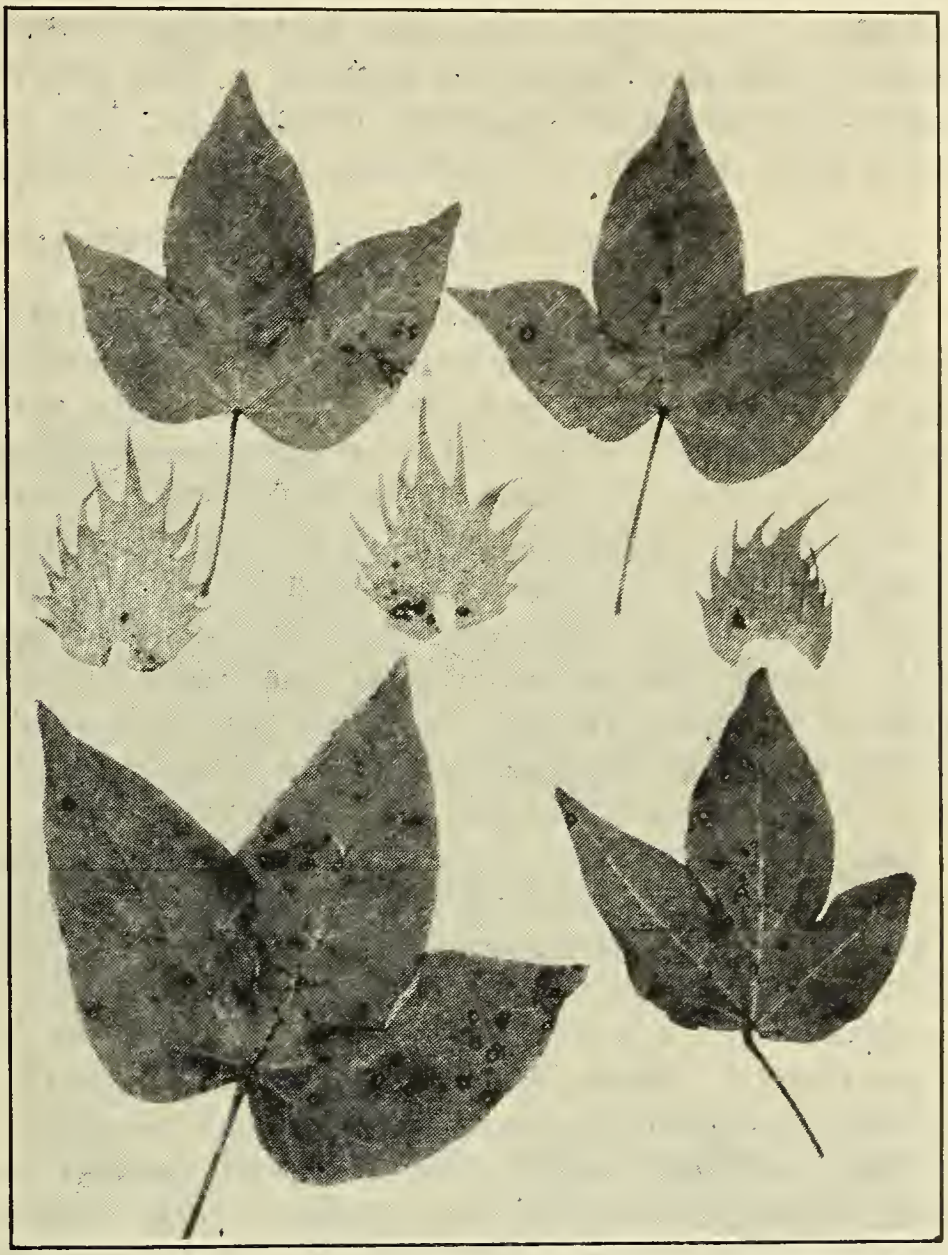

FIG. 10.—Spots on sea-island cotton leaves and bracts produced by spray inoculation with *Helminthosporium gossypii* n. sp. Photographed five days after inoculation

Great care is exercised to prevent the escape of imported strains. Phytophthoras of the faberi-palmivora type have been isolated from coconut, cotton, and tomato in Porto Rico, but the possibility of introducing strains pathogenic to other hosts or more virulent strains is always present. Inoculations of fruits and seedlings are always made in the laboratory under cover and all material is destroyed later by autoclaving; and the glass slides which are used to examine the strains under the microscope, are immediately washed in a solution of mercuric chloride.

Heterothallism has been demonstrated between some strains by other investigators, and the present investigation is intended to test the possibility of oogonia formation with all possible combinations of the 45 strains. Seventeen strains have been grown together to date. In each instance where oogonia have been found one of the inoculating

strains has been isolated from cacao. Two strains from cacao in Trinidad and one strain from cacao in Ceylon produce oogonia when grown in mixed cultures with some of the other strains. All oogonia so far found have been of the *P. parasitica* type.

Phytophthora boll rot of cotton was found in Porto Rico for the first time during the year. A small station planting bearing bolls during the rainy season became infected. The Phytophthora was isolated and reproduced the disease when used to inoculate healthy bolls. The fungus apparently is of the faberi group, but exhibits many dissimilarities to the coconut bud rot strain. Inoculations of coconut palms with the cotton strain have not resulted in bud rot, but, since the organism in the latter case requires a long incubation period, infection may yet appear. The severity of cotton boll rot varies directly with moisture conditions, the percentage of infection being high during rainy periods and low during dry periods.

RHIZOCTONIA FERRUGENA AS A SEEDLING PARASITE

Rhizoctonia ferrugena originally was isolated from the roots of sugar cane. During the year some pigeon-pea seedlings which were growing in pots in the greenhouse were severely attacked by damping-off, and examination of the infected parts showed mycelium characteristic of Rhizocton a. Cultures from the tissue produced typical *R. ferrugena* growth with numerous reddish brown sclerotia and masses of brown mycelium on the sides of the culture tubes and flasks. To determine the host range of the organism, pots of sterilized soil were inoculated with suspensions of macerated bean pod cultures and sown with the seeds of various plants. A check pot was used in each instance, and all the series were duplicated at a later date. On y a résumé of the results of the inoculations can be given here.

The type of injury varies with different hosts. In some instances the seedlings are killed before reaching the surface of the soil, and in others a typical damping-off is evident during the first two weeks growth. Apparently the fungus is unable to enter the tissue once it hardens. As a root parasite the fungus is probab y not of great importance. Hosts which are very susceptible to attack by *R. ferrugena*, as shown by great y decreased germination or by damping-off include cabbage, carrot, Swiss chard cotton, sweet pea, onion, mustard, turnip, cucumber, beet, pigeon pea, chayote, bean, spinach, and lettuce. Tomatoes and *Crotalaria juncea* are only slightly susceptible, and corn, sugar cane from cuttings, sweet potatoes, and Bermuda grass are not damaged.

Experiments to determine the effect of var ous percentages of soil moisture on infection were conducted with beans, pigeon peas, and cotton. Thirty pots of sterilized soil were used for each host. The pots were divided into six groups of five pots each, and all the pots in the same group were given the same amount of water daily. One pot in each group was left uninoculated to serve as a check. Twenty-five seeds were planted in each pot. The average soil moisture was determined by samples taken twice daily. Table 3 gives the results of the test.

TABLE 3.—*Effect of soil moisture on Rhizoctonia ferrugena infection*

Crops	Average soil moisture	Proportion of healthy plants to number of seeds planted		Decrease resulting from inoculation
		Check	Inoculated	
	Per cent	*Per cent*	*Per cent*	*Per cent*
Pigeon peas [1]	34.13	40	3	37
	32.68	70	19	51
	29.03	76	17	59
	16.26	90	55	35
	14.23	84	14	70
	8.71	90	8	82
Cotton [1]	35.38	84	23	61
	32.63	76	24	52
	27.49	80	22	58
	24.34	72	4	68
	16.61	72	3	69
Bean [2]	34.69	60	17	43
	32.91	88	23	65
	30.46	64	24	40
	27.14	80	30	50
	23.19	72	32	40
	16.45	68	44	24

[1] Data taken 20 days after planting.
[2] Data taken 15 pays after planting.

The percentages in the check column were obtained from only 25 planted seeds, whereas those in the inoculated column were obtained from 100 planted seeds. A comparison of the percentages in the latter column is therefore of more value as an index of the effect of varying percentages of soil moisture on infection than is a comparison of the decreases due to inoculation because of the wide variations in germination in the check pots.

Although the results of the experiment are not considered conclusive, they indicate that, in the case of the pigeon pea and the cotton, infection is more serious on dry than on wet soils, whereas, in the case of the bean, the reverse seems to be true.

ANTHRACNOSE OF PIGEON PEA

Anthracnose of the pigeon pea, due to *Colletotrichum cajani*, although previously reported only from Brazil, and possibly from Barbados, has probably been present in Porto Rico for many years, since specimens have been received from widely separated points. The disease is readily recognized by the appearance on the pods of lesions resembling those occurring on beans infected with *C. lindemuthianum*. Since the pod of the pigeon pea is chartaceous rather than succulent, the lesions are more like spots than cankers. In damp weather the centers become pinkish gray, owing to the formation of masses of conidia. The fungus penetrates the pod and enters the seeds, causing them to decay or to fail to develop. Very early infection may cause the pod to shrivel and fall. (Fig. 11.)

In January, 1925, diseased and healthy pods were picked from 10 plants in the station grounds. The pods were at the green-pea stage, at which time they are edible. The peas were shelled and graded as marketable or unmarketable—that is, shriveled or discolored by the fungus. Table 4 shows the number and percentages of diseased and healthy pods and the number of marketable peas per pod.

TABLE 4.—*Marketable seeds in healthy and diseased pigeon pea pods*

Marketable seeds per pod	Diseased pods		Healthy pods	
Number.	*Number*	*Per cent*	*Number*	*Per cent*
0	66	12.1	0	0
1	84	15.4	0	0
2	101	18.5	0	0
3	144	26.5	21	24.7
4	121	22.3	52	61.2
5	28	5.2	12	14.1
Total	544	100.0	85	100.0

The 544 diseased pods yielded 1,342 marketable seeds; whereas from a like number of healthy pods a yield of 2,118 seeds would be expected. The loss attributable to the fungus is 776 seeds, or 36.6

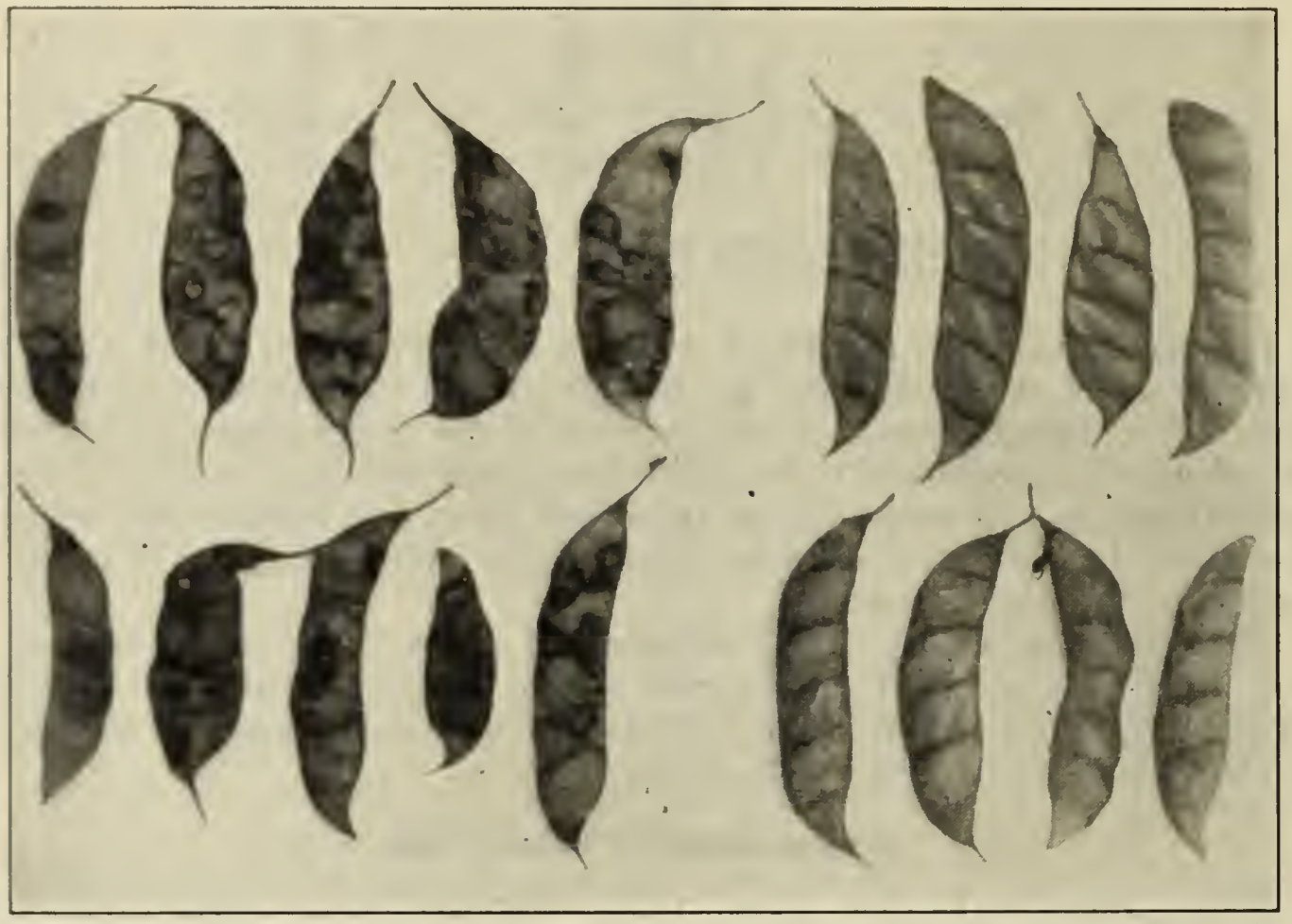

FIG. 11.—Left, pigeon pea pods spotted and distorted by *Colletotrichum cajani*. Right, healthy pods

per cent. Some varieties which are thought to be resistant to infection are to be tested. Attempts to inoculate varieties of beans, including Giant Stringless Green Pod, Pencil-Pod Black Wax, and Refugee, resulted negatively. Parallel inoculations of small pigeon peas resulted in 100 per cent infection, one or more leaves on each plant showing a blackening and shriveling of the veins. All inoculations were made by spraying the plants with an atomizer containing a water suspension of conidia.

STEM CANKER OF PIGEON PEA

Stem canker of pigeon peas every year kills many plants in Porto Rico. The cankers most commonly occur near the ground, but may be found on nearly any woody part of the plant. The wood is killed and becomes brown in elongated areas gradually involving the whole stem. (Fig. 12.) Fragments of brown mycelium were to be seen in scrapings from the diseased wood, and perithecia of a Botryosphæria

were found on the bark. The Botryosphæria was identified by C. L. Shear as *B. xanthocephala*, which attacks the pigeon pea as a saprophyte in India. Cultures from the interior of cankers yielded a brown fungus which is probably the Botryosphæria, although no fruiting bodies have been produced. The results of inoculations with the pure culture are yet uncertain.

A PHYSIOLOGICAL DISEASE OF SISAL

In 1923 attention was directed to a disease of sisal. The affected plants could be distinguished at considerable distance by their yellow, drooping leaves. The leaves had sunken areas of shriveled, yellow, corky tissue varying from a few millimeters in diameter to elongated patches covering nearly the whole of the blade. The mottled appearance suggested a type of mosaic. Affected plants ceased growing, and the yellowing, at first confined to older leaves, gradually extended to even young leaves which had not emerged from the central bud. Plants of all ages were attacked and a number died.

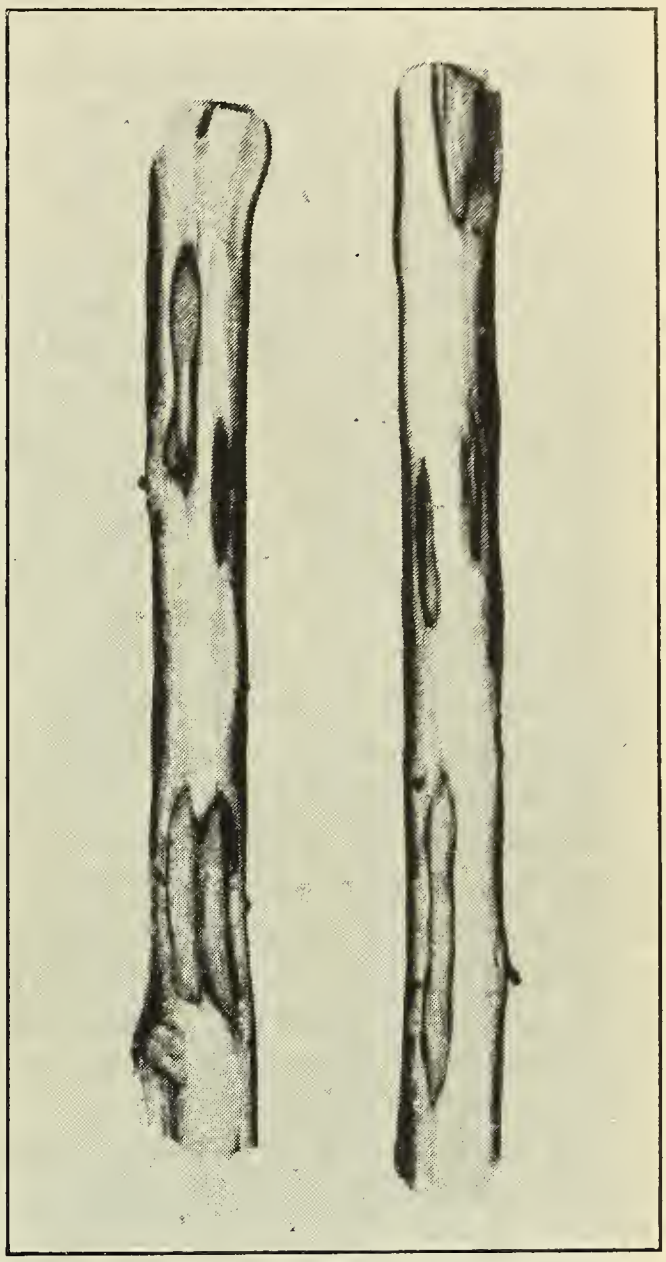

FIG. 12.—Sections of cankered pigeon-pea stems with the bark cut away to show the areas of brown infected wood.

Examination of plants in the incipient stage of disease showed the presence of small, apparently water-soaked, circular areas which proved to be translucent when the leaves were held to the light. Sections of translucent and corky areas failed to reveal the presence of any organism. The corky areas were a series of collapsed and dried mesophyll cells. Plantings of both stages in various culture agars failed to give any growth whatever from bits of tissue removed from the interior of the affected areas. Plants in various stages of the disease when examined showed dying roots in the more advanced stages, but no symptoms attributable to a root disease in the earlier stages. Sisal was severely affected, and some henequen growing in the same locality to a much less extent.

The affected plants were grown on hillsides in a soil of very unproductive heavy yellow clay. The very severe drought of the winter coupled with the torrential rains of the summer rendered the soil almost untillable and probably caused the death of the crop. A dozen young plants which were apparently in the last stages of disease showed complete recovery one year later when transferred to alluvial loam having good drainage. The yellow had been replaced by green and growth was normal. The return to normal of the color would

seem to indicate that yellowing was due to physiological causes rather than to parasite invasion. Recovery of affected parts could hardly be expected in the latter case. Leaf areas which collapsed and became suberized did not recover, but surrounding tissues regained their normal green color and turgidity.

Crosses between henequen and sisal were made to establish progeny combining the disease-resistance ability of the former with the desirable qualities of the latter. The resulting progeny already exhibit great variety in characters, and their ability to resist disease is being watched with interest.

TOMATO DISEASES

Wilt (*Bacterium solanacearum*) is one of the most destructive diseases of the tomato in Porto Rico. The bacteria are thought to gain entrance to the roots through wounds caused in transplanting or later by nematodes, and an effort is therefore being made to prevent infection by immersing roots for transplanting in an approximate ¼ per cent Uspulun solution. Applied in this strength Uspulun is toxic to the bacteria, and apparently not injurious to the plant. Plants when transplanted to dry soil and treated with the solution have grown as well as those receiving only water. The results of using the disinfectant in infected soil are not yet ready for publication.

In a test with 36 varieties of tomatoes and hybrids an average of 60 per cent of the plants became affected with bacterial wilt. The different varieties exhibited considerable variation in number of diseased plants, but no variety showed high resistance to infection. The variety Truckers' Favorite had a mortality of 100 per cent before setting fruit. (Fig. 13.)

Nematode root knot is another serious trouble in tomato growing. Comparisons of seed bed treatments were made, using steam-sterilized soil, formaldehyde (1 part formalin to 50 parts water applied at the rate of one-half gallon per square foot), Uspulun (¼ per cent solution applied at the rate of one-half gallon per square foot), and heavily infected untreated soil. The untreated soils, and Uspulun and formaldehyde treated soils resulted in an infection of 100 per cent of the seedlings. No infection took place in the steam-sterilized soil. The average height of the root-knotted plants was 3.85 inches and of the healthy plants 6.34 inches three weeks after planting. The measurements were from root tip to tip of the youngest leaf.

A ROOT ROT DISEASE OF HIBISCUS

Seedlings resulting from crosses between various varieties of ornamental hibiscus were attacked by a root disease causing wilting and yellowing of the leaves and eventually the death of the plant. An unidentified Pythiumlike organism was isolated from infected roots, but proof of its pathogenicity has not been attempted. The disease is interesting because it was not observed on any of the parent plants. Since the plants are usually propagated by cuttings, only resistant individuals probably have survived.

MISCELLANEOUS PLANT DISEASES

The following plant diseases were observed in Porto Rico during the year:

Avocado.—Anthracnose (*Colletotrichum glœosporioides?*). Green specimens of fruit from a plantation in Villalba, where many varieties

are cultivated, bore spots which were typical of anthracnose. The variety Fuerte was reported to be the most susceptible to the disease. The spotted areas were dark brown, roughly circular, with small black pimples in the center, and, as the fruits matured, became enlarged, sunken, and covered with dirty white masses of conidia, corresponding

FIG. 13.—The two middle rows are Truckers' Favorite tomatoes. Every plant is infected with bacterial wilt

closely with descriptions of *C. glœosporioides*. Cross inoculations are desirable to determine whether the fungus will infect citrus, and possibly the mango.

Banana.—Anthracnose (*Glœosporium musarum*) attacked mature fruits, spotting the skin with brown. Wilt (*Fusarium cubense*) was

very destructive, especially to the variety locally known as Chamaluco. The variety Gros Michel also proved to be susceptible to the disease.

Bean.—Damping-off (*Pythium debaryanum*) severely attacked germinating beans during the rainy period. The fungus has not been previously recorded on beans in Porto Rico. Rhizoctoniose, or hollow stem, was commonly found. Rust (*Uromyces appendiculatus*) proved to be destructive to beans growing in the greenhouse. Leaf spots (*Cercospora* spp.) were so abundantly present in some instances as to cause the leaves to dry and fall. Often two distinct species of Cercospora were present on the same plant. Mosaic disease was frequently observed, the affected plants showing the characteristic symptoms of curling, dwarfing, and mottling. Powdery mildew (*Oidium* sp.) damaged some plants in the greenhouse, and was favored by conditions promoting the growth of the more destructive disease, anthracnose (*Colletotrichum lindemuthianum*). The latter was prevalent only during the cooler season, and was not controlled by spraying with Bordeaux mixture.

Beet.—Leaf spot (*Cercospora beticola*) did considerable damage during wet weather.

Breadfruit.—Rust (*Uredo artocarpi*), seldom found and does negligible damage. Algal leaf spot (*Cephaleuros virescens*), not important.

Cabbage.—Black rot (*Pseudomonas campestris*) destroyed the crop when continuously planted in the same place. Leaf spot (*Alternaria brassicæ*) was found only on old leaves.

Cane.—Leaf spots (*Helminthosporium sacchari*), *Leptosphæria sacchari*, and *Phyllosticta sacchari*). *H. sacchari* was commonly present on old plants and proved fatal to some seedlings. Seedlings at the station were infected severely during even the driest months. The pycnidia of *Phyllosticta sacchari* and the perithecia of *Leptosphæria sacchari* were often found in the same spots, suggesting a possible connection of the forms. Red spot of the leaf sheath (*Cercospora vaginæ*) proved to be of slight importance. Root diseases which may be of considerable importance were found. Soil conditions play an important rôle in determining the amount of damage caused by organisms. Apparently varietal susceptibility varies considerably. Mosaic disease was very serious on susceptible varieties, many of which are being replaced by immune canes.

Cantaloupe.—Downy mildew (*Peronoplasmopara cubensis*) was widely prevalent and increased in virulence with the advent of the rainy season. Under normal conditions the disease may be controlled by spraying with Bordeaux mixture. Usually, leaf spot (*Cercospora* sp.) causes damage resembling that done by downy mildew, and the two diseases may be found on the same leaf.

Cassava.—Leaf spot (*Cercospora* sp.).

Citrus.—Scab (*Sphaceloma fawcettii*) (*Sporotrichum citri*), is the most serious disease of grapefruit in Porto Rico. The groves along the northern coast are very liable to infection. The trees at the station showed little infection this year, but the leaves appearing during the summer are severely attacked. The absence of fruit infection is due to high temperature and scanty rainfall in the blossoming period. Anthracnose (*Colletotrichum glœosporioides*) was occasionally found on the leaves. Not important in this section. Sooty mold (*Capnodium citri*) is common. Algal leaf spot (*Cephaleuros virescens*).

Coffee.—Thread blight (*Corticium koleroga*), which covers the leaves with mycelium causing their death, spreads by means of mycelial strands which follow the branches and twigs. Often the dead leaves remain hanging from the twigs by threads, suggesting the name of the disease. Infection is general during the rainy season, but the damage done locally is not great, probably because the fungus is well checked by the severely dry winters. White-root disease (cause undetermined) is the most destructive of the diseases affecting the station plantings. The earliest symptoms are yellowing and wilting of the leaves. The fungus may be seen at the collar of the trees, where it is present in white strands and patches on the base of the trunk and the roots. Black-root disease (*Rosellinia bunodes*). The symptoms of the black-root disease are similar to those of the white type, differing only in the black fungus which is found at the base of the trunk. The black type is probably more prevalent locally than the white type, but is not present in the trees at the station. Leaf and berry spot (*Cercospora coffeicola*), although usually present, does not cause serious loss. Leaf spot (*Omphalia flavida*), the serious disease of higher altitudes, is not found at the station.

Corn.—Leaf spot or streak (*Helminthosporium turcicum*) is a conspicuous and occasionally serious disease, causing elongated, bleached, dead areas in the leaf blades, in the centers of which the brown conidiophores and conidia of the fungus are plainly visible. Root rot (*Fusarium moniliforme*) has been prevalent at the station in low, poorly drained soils. Loss from the disease varies greatly from year to year. Bacterial wilt (*Aplanobacter stewarti*) severely attacked a planting of hybrids growing on low ground. The hybrids were the result of crossing field and sweet corn. Rust (*Uredo pallida*) is usually present, but does negligible damage. Smut (*Ustilago zeæ*) rarely attacks more than a few plants in a field. The disease is conspicuous when it is present.

Cotton.—Leaf, bract, and boll spot (*Helminthosporium gossypii*). (See p. 28.) Areolate mildew (*Ramularia areola*) is an important fungus disease of cotton leaves under humid conditions. Rust (*Kuhneola gossypii*) frequently occurs on cotton growing wild and on sea-island cotton. Leaf spot (*Phyllosticta malkoffii*) resembles that caused by *Helminthosporium gossypii*, but is of much less importance. Not previously reported from Porto Rico. Phytophthora boll rot (*Phytophthora palmivora*) is of importance during wet weather only. It attacks the bolls, causing them to turn black. The lint and seeds are destroyed. The fungus is not important on cotton in Porto Rico where the crop is matured during the dry season. Not previously reported from Porto Rico. (See p. 30.) Fusarium boll rot (*Fusarium* sp.) is destructive at Mayaguez during the rainy season. Diplodia boll rot (*Diplodia gossypina*). Damping-off (*Rhizoctonia* sp.).

Cucumber.—Downy mildew (*Peronoplasmopara cubensis*), a serious hindrance to cucumber culture, may be controlled by spraying with Bordeaux mixture, unless the rainfall is very heavy.

Eggplant.—Leaf spot and fruit rot (*Phomopsis vexans*) are widely prevalent and destructive during damp weather.

Gliricidia maculata.—Thread blight (*Corticium koleroga*) attack may assume some importance, especially in regions where a well-defined dry season does not hold the fungus in check.

Grape.—Powdery mildew (*Oidium* sp.) is severe on leaves and young fruits, often causing them to drop. Rust (*Physopella vitis*) generally severely attacks the leaves.

Guava.—Anthracnose (*Glomerella cingulata*).

Hibiscus.—Root disease (undetermined Phycomycete). (See p. 34.)

Lettuce.—Leaf spot (*Cercospora lactucæ*) is commonly found on the older leaves. The disease is not important during dry weather, but renders the plant practically unsalable during wet periods.

Mango.—Anthracnose (*Colletotrichum glœosporioides*) causes the death of the flowers and very young fruit during rainy weather. At Mayaguez the fruit trees blossom during a very dry period and a good crop usually sets. In some sections little production is obtained because of rains during the blossoming season. The fungus also causes spots on the leaves. Sooty mold (*Meliola mangiferæ*) is usually present as a black coating on the leaves. Trunk galls (cause undetermined) apparently cause no harmful effects. The large galls frequently form on the trunks and large branches. Leaf spot (*Pestalozzia guepini*) is common but not severe.

Okra.—Leaf mold (*Cercospora hibisci*) is nearly always present on the under sides of leaves which are nearly covered by the dark conidiophores and spores. The leaves turn yellow and fall, and the photosynthetic area is often reduced to a few young leaves at the top of the stalk.

Onion—Anthracnose (*Colletotrichum circinans*) attacks onions of the white type. In localities where the disease is severe losses may be avoided by planting colored varieties. Leaf blight (*Macrosporium parasitica*) causes drying and shriveling of the leaves. It is not of much importance at Mayaguez.

Peanut.—Rust (*Uredo arachidis*). Leaf spot (*Cercospora personata*).

Pepper.—Leaf spot (*Cercospora capsici*) is a widely prevalent disease causing considerable loss. The spots are large and bleached, and cause infected leaves to fall, often resulting in nearly complete defoliation. Anthracnose (*Glœosporium piperatum* and *Colletotrichum nigrum*) attacked approximately half the plants in one planting. The fungi cause rotting of the ripening fruits. Wilt (*Fusarium* sp.) has been prevalent in heavy soils. Infected plants wilt during the day and revive at night for a short time, then turn yellow and fall. Sixteen per cent of the plants on heavy soil (clay) were killed by the disease. Usually the attack was delayed until the plants were fruiting. Investigation will be necessary to determine the exact species found in infected stems. Not previously reported from Porto Rico. Mosaic disease affected plants received from San Germán. The leaves were wrinkled, dwarfed, and distorted, and the internodes were shortened, producing a bunchy effect at the top of the plants. The plants failed to produce, and the leaves failed to show the yellow mottling characteristics of the disease in beans. Southern wilt (*Sclerotium rolfsii*) occasionally kills a plant, but the disease is less important than the Fusarium wilt.

Pigeon pea.—Rust (*Uromyces dolicholi*) is very commonly present, especially on old leaves, but apparently is not very destructive. Anthracnose (*Colletotrichum cajani*) is present on pods and leaves. (See p. 31.) Stem canker (*Botryosphæria xanthocephala*) is a serious disease causing the death of many plants. (See p. 32.) Damping-off (*Rhizoctonia ferrugena*) is very destructive to seedlings during wet

weather. (See p. 30.) Leaf spots (*Velosiella cajani, Cercospora instabilis*) are commonly present. The spots are rather inconspicuous and are similar to those caused by *Colletotrichum cajani*, and are not very important. The genus Velosiella was separated from *Cercospora cajani*, on account of the catenulate conidia.

Rice.—Brown spot (*Helminthosporium oryzæ*) has assumed considerable importance in variety trials at the station. Fifteen per cent of the seedlings die as a result of the fungus invading the roots and collar. Older plants are attacked and the leaves thickly spotted. Spots appear also on the glumes and the fungus is transmitted to the seed. Efforts to control the disease by treating the seed with formaldehyde, Uspulun, copper sulphate, and hot water have not given sufficient success to justify recommendation of seed treatment. Blast (*Piricularia oryzæ*) is not of frequent occurrence.

Rose.—Powdery mildew (*Oidium* sp.) was found on leaves of roses received from Salinas. It yields readily to fungicides. Leaf spot (*Cercospora rosicola*) is abundant but not destructive.

Roselle.—Root disease (*Rhizoctonia* sp.?) was noted for the first time during the year. A Rhizoctonia is constantly present in diseased roots, but its connection with the disease has not been established. The disease is very destructive and the infected plants die rapidly.

Sisal.—Anthracnose (*Colletotrichum agaves*) is frequently present and of considerable importance. Not previously reported from Porto Rico. Physiological disease (see p. 33).

Sorghum.—Rust (*Puccinia purpurea*). Smut (*Sphacelotheca sorghi*).

Sweet potato.—Java black rot (*Diplodia tubericola*) blackens the interior of roots, which lose weight, shrivel, and turn grayish, and finally black, covered with the fruiting bodies of the fungus. The disease appears occasionally at the station, but has not caused serious injury. White rust (*Albugo ipomoææ-panduranæ*) is commonly found, but does no serious damage. Leaf spot (*Cercospora* sp.) is of minor importance.

Swiss chard.—Leaf spot (*Cercospora beticola*) attacks the leaves during rainy weather and renders them worthless.

Tobacco.—Leaf spots (*Cercospora nicotianæ* and *Phyllosticta nicotiana*). *C. nicotianæ* was found on tobacco at the station, and *P. nicotiana* on leaves received from Corozal. Mosaic disease curls and mottles the leaves.

Tomato cultivation is successful only during the dry season. Bacterial wilt (*Bacterium solanacearum*) is the most serious disease in this region. Leaf mold (*Cladosporium fulvum*) causes the leaves to turn yellow and fall. The fungus is present on the under surfaces as an olive-colored mold. Spraying thoroughly with Bordeaux mixture is efficacious in controlling the disease, except under conditions of extreme humidity. The disease ranks next to the bacterial wilt as a cause of loss. Blight (*Phytophthora infestans*) rarely causes loss here. In March an outbreak occurred among the station plantings. The weather was cool and rainy, and after a few days of warm, dry weather the disease disappeared. Leaf spot (*Septoria lycopersici*) was found at Garrochales, where it was confined generally to older leaves. Mosaic disease was severe at Garrochales. Infected plants were so mottled and dwarfed as to be worthless.

Vanilla.—Rot (*Glæosporium vanillæ*) attacks only vines which are in very shaded and moist situations and is negligible as compared with root disease. The disease is conspicuous and blackens and rots an occasional vine. Root disease (*Fusarium* sp.) is exceedingly destructive. (See p. 26.)

Watermelon.—Anthracnose (*Colletotrichum lagenarium*) is the greatest hindrance to watermelon growing. The crop is often planted in low, rich valleys where the humidity is high. Under such conditions the anthracnose fungus is difficult to control, even by frequent sprayings. Mycosphærella wilt (*M. citrullina*) is found occasionally. Covering the infected stems with earth has enabled most of the vines to mature their fruit.

Yam.—Leaf spot (*Cercospora carbonacea*).